Is It The Real Thing?

As the costs of simulation technology have come down, the debate about the value of driving simulators as a method for training drivers has gathered momentum. Drawing on evidence of the effectiveness of simulators for training aircraft pilots, there is a growing belief that driving simulators can be used in a similar way to improve hazard anticipation and decision-making in critical traffic situations.

The relevance of this technology for learner drivers is obvious: One of the major factors thought to be responsible for the increased risk of novice driver crash involvement is the failure to anticipate hazards and manage risk. This is believed to be due to inadequate exposure to the traffic and road scenarios that help to develop predictive mental models, which the more experienced drivers realise might result in a collision. Since novice drivers have had less contact with traffic, and less time to develop and refine their mental models, they are less able to correctly predict the likely development of traffic situations.

In this regard, simulators could offer a number of potential solutions for learner driver education, including:

- Presentation of high risk scenarios that are impossible to carry out in the real environment because of the inherent dangers
- Standardisation of training materials in a controlled environment
- Repeated performance of the same task until a benchmark is reached
- Hazard anticipation training to improve risk awareness
- Risk management training to improve decision-making
- Analysis of task performance to enhance learning with repeated trials
- Use of instruction and variation in scenarios, depending on previous responses

Whilst these are obvious advantages, there are still many valid questions about the use of simulation technology for training purposes: Do simulator trainees take driving simulators seriously? What kind of simulator would best serve learner drivers' needs? How realistic does a simulator need to be for learning to take place? What is the evidence that learning acquired on a driving simulator is transferred to the real world?

When reviewing the literature of simulator-based driver training, the answers to these questions are hard to come by. Recent research at Cranfield University has gone some way to investigating these issues, and a summary of the most important issues will now be discussed.

It's Just A Game? Psychological Fidelity

Do trainees take driving simulators seriously? Many people intuitively believe that if the user perceives a simulation as being realistic, their behaviour is more likely to mimic that performed in the real environment, but research shows that this is not necessarily the case. Perception of simulator realism is dependent on the driver's level of experience in the real system. For the expert or experienced driver, even a high fidelity (top of the range simulator) vehicle is not judged to perform like the real thing. Interestingly, these are the very people that often make judgements about the validity of systems, and are left wanting. Despite the views of expert or highly experienced drivers, the research seems to suggest that for the novice driver, lack of experience of driving in a real vehicle means they are less distracted by the artificial nature of a simulator. In other words, they have not yet developed the sophisticated mental models and benefit more from exposure to a simulator compared with their more experienced counterparts. Indeed, at Cranfield, we find that whether or not a driver considers the simulation to be realistic, does not seem to have any impact on the way they perform during training. In other words, drivers with a more negative attitude to our driving simulator did not significantly differ in their driving performance compared with those drivers with a more positive attitude (Muncie and Dorn, 2003). Previous research using flight simulators has revealed similar findings.

Physical Fidelity

Physical fidelity is achieved if there is a high correlation between the physical features of a simulator and the road environment being replicated. With perfect fidelity, a training environment would be indistinguishable from the actual task environment. High-fidelity simulators (often referred to as 'top-end') are characterised by very sophisticated visual image generation systems, advanced vehicle dynamic models and complex motion bases. These kinds of systems are more often used for research rather than training purposes.

Organisations need to know what level of driving simulator fidelity is required for learning outcomes to be met. Engineers and system designers often assume that the greater the physical fidelity, the greater the training effectiveness. However, research shows that the importance of physical fidelity appears to depend on the nature of the task being trained. For instance, if decision-making skills are being evaluated, then (based on studies conducted using flight simulators) high-fidelity vehicle handling characteristics are unlikely to be important. Very realistic experiences can be achieved without fully replicating the real world, so long as the features of interest for training purposes are replicated. This is referred to as 'functional fidelity'.

There is also growing evidence from flight simulator studies that intentional departures from reality (abstracting or augmented displays) might actually enhance skill acquisition by focusing the trainees' attention on specific task-related issues during training, especially in the case of novice operators.

This poses the problem that although simulators might be categorised according to their level of fidelity, this does not help organisations decide whether the simulator is suitable for the kind of training they want to undertake.

SIMULATOR CONFIGURATION	CHARACTERISTICS
	**NFOVD:** Single monitor, desktop; 45° field of view; 50% image size; Sidewinder game controls; Iconic side view mirrors; Two School Districts; Students in driver education classes; One trained in computer lab; Second trained in back of classroom
	**WFOVD:** Three monitor, desktop; 135° field of view; 50% image size; Sidewinder game controls; Real image side-view mirrors; Students recruited at local DMV office; Trained in laboratory environment and supervised by researchers
	**WFOVC:** Three channel projected image; 135° field of view; 100% image size; Instrumented cab; Real image side-view mirrors; Students recruited at local DMV office; Trained in laboratory environment and supervised by researchers

Figure 1. Simulator Configurations

Is The Simulator Any Good?

Organisations need to be satisfied that the system they have procured is valid. Many simulator manufacturers and organisations make the mistake of assuming that a driving simulator is a valid measure of driving behaviour, based on validation studies on other driving simulators. But studies are not routinely conducted on a new system to assess validity, and they should be - there are several components of the system that may interfere with learning.

Simply comparing the differences between several performance indicators during both real-life and simulated driving can validate a simulator.

Relative validity can be achieved if performance data in both the simulator and the real vehicle (i.e. preferred speed on a particular type of road, and under similar kinds of conditions, in both training mediums, by the same driver) is relatively similar.

That'll Learn Them

The most important criterion for judging the effectiveness of the simulator in training is whether the skills learnt on the simulator are transferred to driving on the real road. This is particularly important for training purposes and is often referred to as behavioural validity. To my knowledge, there is only one publication that demonstrates this transfer of training effect from a driving simulator in terms of reducing accident rates amongst learner drivers under different conditions of physical fidelity. In the US, 553 learner drivers drove different configurations of a simulator to investigate whether simulator fidelity affected transfer of training effects, by comparing different configurations on accident rates (Allen, Park and Cook, published in Dorn, 2008). The findings showed that drivers taking part on simulators with a wider field of view monitor system had a significantly decreased accident rate post-licensure compared with those that were trained on a single monitor presentation (see Figure 1).

The implications are that full-size, wide aspect ratio images may provide an affordable answer to simulator-based training, and could be provided by flat panel and projected displays in the future.

Early Days

Currently, the academic literature offers little guidance about the optimum content and delivery of simulator-based driver training programmes, so organisations are often guided by simulator manufacturers about what their system specification should be. Organisations are also often restricted in the kinds of scenarios these manufacturers offer, with little flexibility to design their own training programmes to their specific needs. If they can tailor it effectively to their needs, the cost is prohibitively high.

When procuring a simulator, organisations should choose a system that is not only flexible for their current and future needs, but also captures performance data so that feedback can be given to trainees. It is the feedback that appears to be most influential in the development of the key skills required for safe driving. However, the problem is that, very often, systems with good visual qualities use up larger amounts of computational power, leaving little capacity to record performance data and feedback. Organisations investing in a simulator system must ensure that the manufacturer is able to show that their system has been validated, independently, as manufacturers like to present their own data as evidence of transfer of training effectiveness - often not having been subject to peer-review. Moreover, the manufacturer's validation data will not have been collected for the specific training programme the organisation would like the simulator to provide.

Driving simulators offer distinct advantages, but until the research has been conducted to ascertain the context under which they are most effective, organisations are simply taking a leap of faith. Whilst technology advances at a pace, and their potential increases, there is a pressing need for scrutiny and authoritative reviews of practical simulator use for the learner driver industry. adi

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