

Pedagogic aspects of simulator training

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Abstract

Increased application of driving simulators in the domain of driver training is desirable for ecological, economical and didactic reasons. Among the benefits are low physical risks for a trainee, possibility to repeat a wide range of situations, high controllability of situation and possibility to train for situations that occur rarely in the real life. However, simply experiencing a simulated environment does not mean an effective training. Simulation must be used in a thoughtful, well-planned manner that includes identification of training needs, proper design of scenarios, appropriate performance measurement and feedback to the learner. Optimal didactical approach should be very important when considering the whole simulator training process. Driver education is a long-life learning process and the usage of driver simulators in driver training creates a new learning environment. A wide range of methodological and pedagogical approaches should be taken into account in developing new learning programmes with use of driving simulators. In this paper different pedagogic aspects and traces main approaches to learning such as behavioral, cognitive and socio-cultural and relational perspectives are mentioned. The paper also deals with best practices in driver simulator training (both basic training and enhanced education). Some main conclusions are delineated, based on knowledge coming from European projects on driving simulators, and other available literature.

Although a lot of research with regard to driver simulator training and driver training in general has been done, in projects such as TRAINER, GADGET, BASIC, VIRTUAL, DAN and various experimental studies, there is still a need for the proper guidelines for driver training strategies. Still there is not very much specific knowledge. Some researchers (Emmerik et al., 1999) point out that research on training simulators pays too little attention to didactic aspects of training. Instead, much emphasis is laid on fidelity. However, it is the training programme that largely determines the effectiveness of training. In this paper, the conclusions mainly from the TRAINER projects are described concerning several instructional strategies of training and driving simulator design with the goal provide guidelines for the overall, effective training design. For setting the effective learning activities in driver education, it is needed to first review the ways in which tools are being used to support learning along with a summary of current theoretical understanding of learning and how these might be applied in driver simulator training.

Training process is influenced by a set of inter-related factors. Biggs (1999, In Conole, 2005) describes good pedagogical design as ensuring that there are not inconsistencies between curriculum, teaching methods, environment and assessment. Learning activities in general occur within a particular context, and are designed to meet a set of specified learning outcomes and assessment criteria through a series of tasks using a set of tools and resources. Creating the most effective conditions for learning therefore requires an understanding of each of these factors in their relationship.

As simulation is a unique learning environment, we need to take into account also an educational theory and instructional design. Simulation allows a wide variety of theories to be used. Understanding how we learn allows us to tailor simulation to individuals and groups. Once a theory or theories have been chosen for the particular area of focus within the simulation environment, a structured design for the education basis must also be taken. Using an instructional design model, planning, implementation, and evaluation of courses and programs becomes more structured. Regardless of the educational theories supported by each provider of simulator training, instructional design theories could be integrated.

The use of simulator training means that teachers enter a new environment. Knowledge and training have been viewed from the perspectives of three different traditions: the behaviorist, the cognitive and the relational. Behaviorism was in the first part of the 20. Century established as a prominent school of psychological thought. This perspective presupposed that the learner should always receive an immediate response. Learning was linked habit; it was the result of processes of trial and error. According behaviorism, knowledge is acquired within a system of stimuli and responses, a system in which *reinforcement* plays a central role. When behaviorists were criticized for having given too mechanistic explanation of the learning process, cognitive approach focuses on human information processes (such as perception processes, memory processes, thought processes or memory processes). Learning involves concepts, structures and knowledge.

The associative perspective of training and learning focuses on behaviour modification via stimulator-response pairs, trial and error learning, learning through association and reinforcement, and observable outcomes. It is a part of behavioral theories.

The cognitive learning perspective views learning as transformations in internal cognitive structures (Conole et al., 2005). Pedagogically, it is characterized by processing and

transmitting information through communication, explanation, recombination, contrast and problem solving. The approach is constructivist.

The most recent addition to learning theory is the relational perspective. This criticizes both behaviorism and cognitivism. The main part of the criticism is that they consider learning as an individual activity. The relational perspective states, “intelligent acts can not be understood by analyzing isolated individual behaviour.” There is a need to look at the relations between the learner and the environment in which learning occurs (Ludvigsen, 1996, In Ohra, 1998). Learning is situated, which means that it takes place in the concrete situations or contexts. In other words, this perspective focuses on the contextual and social aspects of learning and thinking. Knowledge is gained through interaction with others and must therefore be understood as a socio-cultural phenomenon.

It is also important to be aware of the fact that a safe driver is not only skilled one but also is aware of risks and his/her own abilities. Obviously, the training of basic vehicle handling skills is basic of a driver training. The advantages of training these skills in driving simulator are safety, ecologically and economically related, and moreover offer the possibility for trainees to learn how to handle new technical devices. They also could experience different types of vehicles. In the simulator, trainees can evaluate their skills by comparing their own decisions and estimate with normative decisions and estimates and perceive the eventual consequences of driver behaviour (Dols et al, 2001).

One of the main outcomes of the BASIC project (Siegrist, 2003) was the set of requirements of ideal educational systems. The requirements are:

- Clear goals and contents for training
- Enough feedback to improve behaviour and to learn
- Theoretical and practical training supporting each other
- Possibility to get enough experience
- Valid environment to practice necessary skills
- Long enough learning period that makes consolidation of skills and knowledge
- Learning climate favorable for safety

Simulation literally means to imitate or in general to refer to something unreal. Simulators can be divided into categories according to their field of use. Paunonen classifies the process training simulators into three categories (Paunonen 1998, In Lindfors, 2002): Basic operation training simulators, functional training simulators and process simulators.

Simulation is a way to gain practice before facing excessively complicated real problems. Simulation helps to understand the dynamics of different systems and to search for the boundaries of the possible and the impossible (Lifländer 1994, In Lindfors, 2002). A functional training simulator contains a functional model of the process. The process model is not very accurate but provides the operator with information on how the process will behave and how it should be operated (Paunonen 1998, In Lindfors, 2002).

In the following figure (according to Garland, 1998), different components of driver training process are described. The important thing is that training does not should be considered separately from the context of training, so we should take into account its objectives, initial state of trainee, instructor and his/her qualification, and assessment and feedback criteria.

Figure 1: Training material in perspective (according to Garland, 1998)

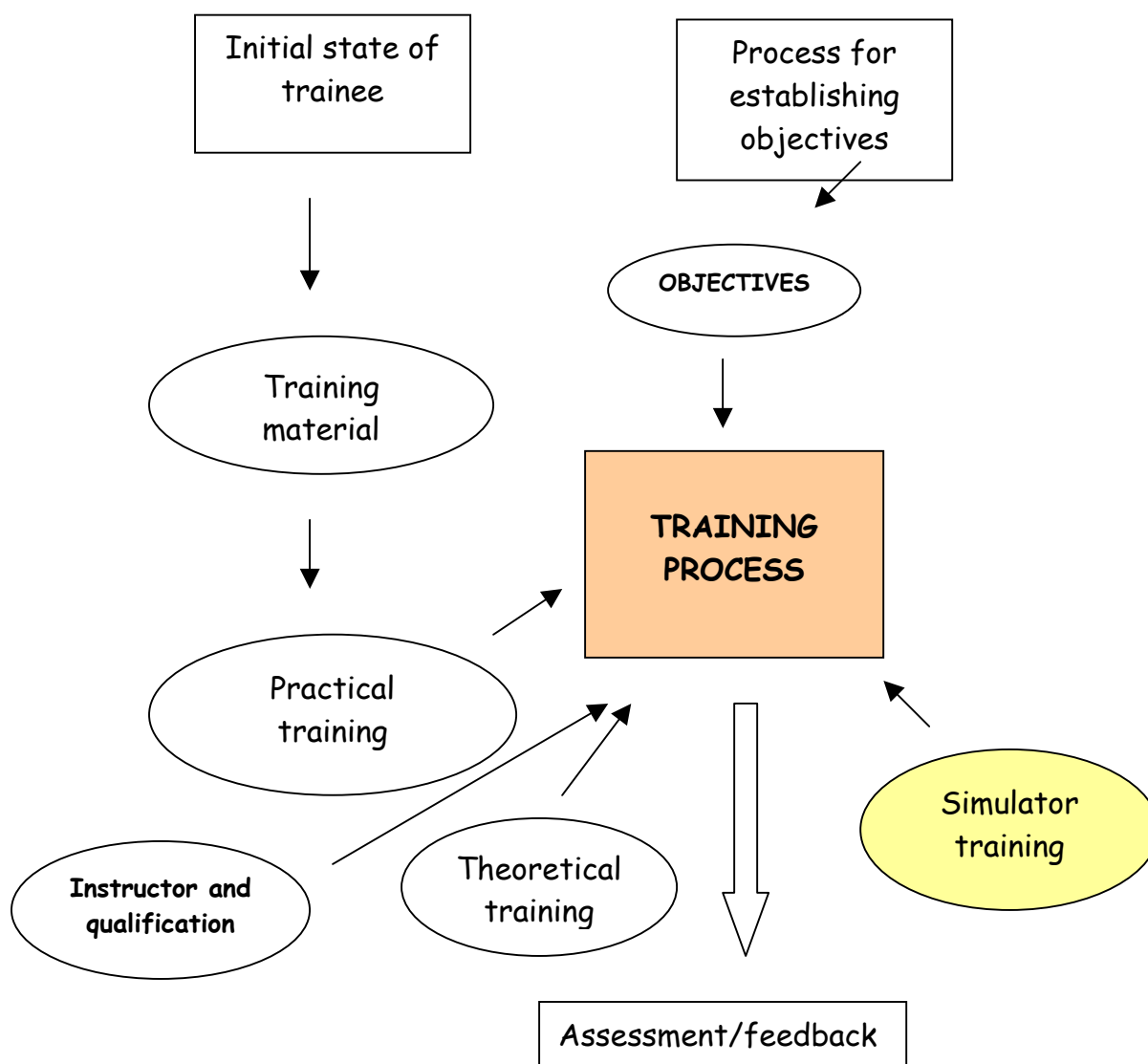
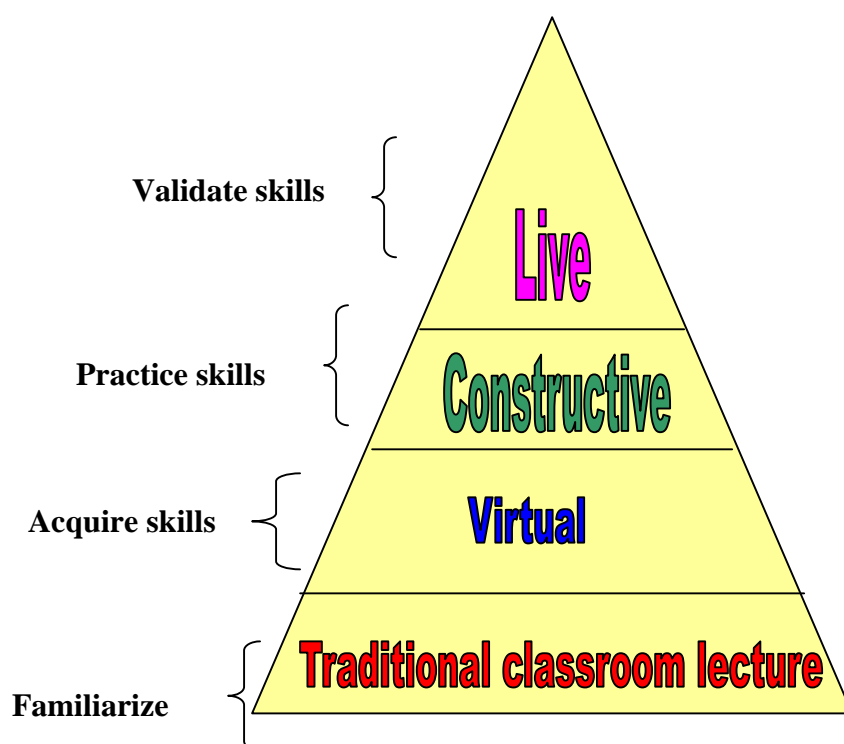


Figure 1: Training material in perspective (according to Garland, 1998)

Figure 2: The “Training Triangle” – maps steps of training methods (according to Lindsey, 2004)



Among the most important practical reasons for using simulators in driver training, we should note that important abilities needed for the execution of operational tasks cannot be trained in a real system, and thus they are carried out in simulated systems. According to Sanchez et al., 1999, In Gregersen et al., 1999), we conclude that among advantages for using simulators for training, are:

- They allow evaluating situations that would imply a certain degree of risk for the drivers, in case of taking place in the real life (Ahmad, 1997; Cox, 1997; Delhomme, 1991; Fuller, 1990, In Gregersen et al., 1999). In this way, they can reproduce dangerous traffic conditions, while the trainee can be subjected to distracting stimulus taken place by the incorporation of new technologies in the automobile (mobile telephones, GPS, etc.)
- They allow to measure the behaviour of drivers in a much more precise way and with a smaller cost (Schiff, 1994, In Gregersen et al., 1999) than studies carried out under natural conditions, using for example, instrumented cars.
- Reproducing the same traffic conditions for several drivers is relatively easy in a driving simulator, while driving in real vehicles the conditions can significantly vary for each test and the comparisons among the drivers can be very complicated. Simulators allow isolating the undesired effects and maintaining those in which we are more interested.

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- They allow simulating the required environmental conditions, to prolong the experiments to the necessary time, and to impose the preferred frequency in the appearance of certain events during the driving.

Korteling et al (1997, In Falkmer et al., 2000) propose the subdivision of the term reliability: physical reliability (simulator behaviour characterized by its mathematical model) and psychological or functional reliability (relating the similarity of the behaviour of the user in the simulator in front of the real system). In some cases, the effort is focused in reaching a high level in the physical reliability of the simulation. The physical reliability level needed to reach functional reliability related to the type of task to train, the skill level, the performance level desired, and finally, to the human factors.

The simulators developed within the TRAINER project (low cost stationary driving simulator for driving schools, mean cost semi-dynamic simulator) are used as:

- Driver's training tool for complex and safety critical driving scenarios in driving schools, as a driver assessment tool
- Driver's assessment tool (for particular driver subgroups, elderly and disabled, standard drivers)

The main objectives for simulator development were:

- To develop appropriate scenarios to support driver training and assessment by the use of simulators
- To develop a low cost driving simulator to support driver training in tactical and control tasks (according to Michon model)
- To develop a mean cost driving simulator with high reliability for support and assessment of particular driver groups

Some conclusions of TRAINER project regarding simulator requirements are:

- All driving simulators are good for training on how to avoid dangerous situations but not how to handle them (so important is how to avoid implementing emergency negotiation scenarios)
- The simulator should not be used for a complete driver training but only for specific tasks, in order to avoid learning and automatising skills in an artificial environment

For which learning tasks should we not use the simulator? According to TRAINER project, risky situations should not be used too often, in order not to create to the trainee the feeling of an unnatural environment. Simulator training should be always monitored by an instructor and preceded or followed by relevant actual car training sessions. Simulators should be used for limited hours, as driving should not be trained on them. The trainee should learn "car feeling"

by driving an actual car. Very complex scenarios, involving many cars, may not be well represented in simulators and therefore should be avoided. Risk awareness should be trained in simulators but not risk handling.

Among some main conclusions in the European project TRAINER is that sometimes it is too frequent that the design of the training program begins when the simulator has been built already. This means that this program should be adapted to what has been already developed, instead of identifying requirements as a function of the necessities. According to Nilsson (1993), to investigate the complete driving task and understand when the reaction of the driver as well as maneuverability of the vehicle plays an important role in the system, the establishment of the simulator requirements is an important step. Therefore, for such types of simulators it is necessary to have a certain design approach, which should include characteristics such as:

- The simulator should work in real time.
- The descriptive model of the vehicle should be complete, and all the subsystems like the motor, controls, transmission, steering system, suspensions, etc. should be modeled.
- The descriptive model of the characteristics of the vehicle should be able to represent a wide spectrum of handling possibilities, for example vehicles with front and rear wheel drive, and different under steering and over steering levels.
- The model of the vehicle should also be able to reproduce the effects of the existent interface between the vehicle and the highway, for example to simulate sliding surfaces or highways with gravel.
- The simulator should have a visualization system with a wide angle of vision. And the images should have enough detail to provide a decent impression of realism.
- The simulator should have a dynamic base.

Low cost driving simulators should be centered in those tasks that can be trained with a relatively cheap hardware (Kappé, 2000). Such hardware is more available today. Also, cost-effective driving simulators should exploit the maximum effectiveness of the training given by a certain hardware configuration, which not only requires an elaborated package of software, but also instruction services that partly reduce the advantages of a training simulator. Therefore this is not an isolated system, but rather it should be an integral part of the traditional program of training that is carried out in the driving schools.

Training simulators for young drivers should be able to instruct a great variety of abilities and aptitudes associated to the driving. A simulator with a good fidelity should be able to train the basic psychomotor aspects (control of the steering and speed) under more complex conditions. Even more important, a simulator with a good control in the scenarios can teach a wide range of cognitive abilities that are required to deal with complex roads and conditions of difficult traffic, including appropriate situation awareness, hazard perception, decision taking and defensive techniques of driving. A simulator can teach the student from a sure and repeated way to situations of danger and to give to the driver experience in the perception and decision taking tasks required.

User's interface is one of the most important parts in the development of the software, as it is 'the guide', which indicates to the student in each moment, in which step of the program he or she is and how he/she can advance or go back. This is the reason, which the design of this part is very important. The interface should be very intuitive and it should allow the student to navigate in a very easy way.

There are (according to TRAINER project) several principles to keep in mind when designing a software interface, which can be grouped in four different categories:

1. Those that reflect Perceptual operations.
2. Those related with the concept of mental model.
3. Those related with the Human attention.
4. Those related with the Human memory.

First of all, in connection with the perceptual principles there are several aspects to keep in mind as:

- The elimination of *absolute judgments limits*. For example, in a decision based on a map of colors, we could have several tones for the same color and this could induce judgment errors.
- *Top-down processing*, People will perceive and will interpret signals in accordance with what they expect to see, based on their previous experiences.
- Be more likely to be interpreted correctly. In particular, if the same message is presented in different ways as message in screen, sound, etc, its understanding will be higher.
- *Discriminability*, Similarity causes confusion. The design should suppress unnecessary similar characteristics and stress the differences to create a higher distinction.

When the user perceives the interface, often interprets to what it looks like, and he/she thinks how it works in relation to his/her expectations or mental model of the system. Thus, the principle of pictorial realism should be applied, which means that the display or interface should resemble the variable that it represents, for example through a drawing, picture, icon, etc.

Another principle is the principle of the moving part. According to it, the elements moving through the screen and their dynamic information should have a direction and a space model, which should be compatible with the mental model that the user has about the movement of that object.

Related to the principles based on attention, complex multi element displays require processing three components of the attention:

- *Selective attention*, which is necessary to choose the sources of information shown for a given task.
- *Focused attention*, which allows to those sources to be perceived without distraction from next sources.
- And the *divided attention*, which allows the parallel processing of two information sources if a task requires it.

For all these reasons we can consider that the TRAINER simulators interface should gather a series of minimum requirements, which are:

- The interface should be user-friendly. This can be achieved through the use of icons, pull-down menus, windows, drawings, etc., which should realize the navigation over the s/w environment in the most graphic mode possible.
- It should exist a users control and identification, since this would allow a better control by the driving teacher and for controlling the training progress. Thus, the option entering the software through a personal password is very interesting.
- It should also have, a possible selection of the scenarios or some predefined scenarios, as consequence of a training program or as a consequence of a program that is focused to improve the student's abilities.
- The interface should show messages of several types on the screen, like errors made during the simulation, warnings, instructions of the scenario, etc. Moreover sounds have to be included.
- Another interesting option that the interface should include is the student's training history, mainly with relationship to the last lessons and statistics of all type.
- It should also include, the possibility to see a replay of a scenario through an air view or from the interior of the vehicle, etc., to the student to see the succession of events taken place after the simulation.
- And of course, information should be included with respect to the technical support of the simulator that is always recommended for the driving schoolteacher and for the student, allowing also a feedback to the supplier of the simulators.

The general approach for simulator training should be based on these conclusions:

1. There should be no inconsistencies between curriculum, training methodologies and assessment
2. Training design should not exist without the learning context
3. Various variables in the training process should be taken into account, such as initial state of training, objectives of training, qualification of the instructor and assessment criteria)
4. The simulator should not be used for a complete driver training but only for specific tasks
5. Each training scenario should be accompanied by clear instruction
6. The aim of the training should be clearly defined, as well as the results should be discussed
7. Awareness of the fact that training of maneuvering skills may result in overconfidence of the group of young drivers
8. Training can only be successful, if it covers the whole range of self-evaluation aspects)

9. Simulator training should be always monitored by an instructor and proceed for followed by relevant car training sessions
10. An important emphasis should be taken to the performance assessment and feedback, more research should be done on the role of the instructor which plays during the whole training process
11. Need of harmonization of European syllabuses for driver training, programmes, requirements for simulators, exams and training instructors
12. Focus on training issues regarding different categories of drivers (professional drivers, for example truck drivers, bus drivers, dangerous goods vehicles' drivers, emergency vehicles' drivers etc.)
13. Ways of integrating driving simulators with traditional training

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