Scientific Framework of CBT and driving simulator application in professional driver training

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Lifelong Learning Programme

Abstract/ Summary

This report is designed to provide an overview on the relevant educational theories and instructional design principles that should be considered when developing CBT and SBT. The investigation undertaken revealed that currently no instructional design principles or educational theories are taken into consideration in the development of SBT in the partner countries, and that only in some of the countries limited basic principles are drawn upon during the development of CBT. However, such foundations are essential in order to guarantee high quality and effective learning by means of CBT and SBT. Different theoretical assumptions on learning lead to different instructional design principles (i.e. a behaviouristic learning environment may be the most appropriate for the learning of facts, whereas the adoption of a constructivist perspective may be more useful for developing problem-solving capacities). Therefore, computer- or simulator-based training for professional drivers should build on the rich sources of educational theory and instructional design as this will enhance content retention and facilitate the transfer of learning into practice. The four pilot trainings developed and tested in work package 3 of the ICT-DRV project (three simulator-based training projects and one computer-based training scheme) began with an evaluation of theoretical considerations and instructional design principles. Several recommendations can be derived both from the literature review conducted for this report and the pilots developed and tested in the project. The following recommendations therefore represent important principles which should be taken into consideration when developing CBT and SBT for professional drivers:

- Learning is a social process - therefore CBT/SBT should allow student/tutor exchange;
- Provide some kind of tutoring in CBT/SBT for professional drivers;
- CBT and SBT should have clear learning objectives and learning outcomes;
- Consider prior abilities and the working reality of professional drivers in CBT/SBT;
- Combine theoretical and practical exercises in CBT/SBT for professional drivers to facilitate practice transfer;
- Train-the-trainer in the use of CBT/SBT as a learning medium;
- Document learning outcomes of professional drivers in CBT/SBT

Abstrakt/ Zusammenfassung

Dieser Bericht bietet einen Überblick über relevante Bildungstheorien und Ansätze des Instruktionsdesigns, die bei der Entwicklung und Umsetzung von Technologie-gestütztem Lernen berücksichtigt werden sollten. Eine Erhebung, die zu Beginn des Projekts in den teilnehmenden Ländern durchgeführt wurde, zeigte, dass derzeit in der Entwicklung und Umsetzung von Simulator-basierten Trainings in den teilnehmenden Ländern weder bildungstheoretische noch Überlegungen hinsichtlich des Instruktionsdesign gemacht werden und nur in einigen wenigen Ländern solche Überlegungen in der Entwicklung und Umsetzung von computer-basiertem Training eine Rolle spielen. Allerdings spielen solche Überlegungen eine wichtige Rolle, um qualitativ hochwertige und effektive Technologie-gestützte Aus- und Weiterbildungsprogramme zu entwickeln. Diverse theoretische Annahmen zu Lernen führen zu unterschiedlichen Instruktionsdesigns (z.B.: eine behaviouristische Lernumgebung ist gut geeignet um Fakten zu Lernen, wohingegen eine konstruktivistische Lernumgebung für die Entwicklung von Problemlösungskompetenz besser geeignet ist). Daher sollten computer- und Simulator-basierte Aus- und Weiterbildungsprogramme für Berufskraftfahrer / Berufskraftfahrerinnen bildungstheoretischen Übelegungen miteinbeziehen und einem – für den jeweiligen Kontext passenden – Instruktionsdesign folgen, da dies sicherstellt, dass das Gelernte behalten wird und in die Praxis transferriert werden kann. Die vier Pilottrainings, die im Rahmen des ICT-DRV Projekts entwickelt wurden (drei Simulator-basierte und ein computer-basiertes Training) begannen mit theoretischen Überlegungen und gründeten auf Annahmen des Instruktionsdesigns. Auf Basis der Ergebnisse des Literaturüberblicks sowie der entwickelten und getesteten Pilottrainings können einige Empfehlungen gemacht werden, was bei der Entwicklung und Umsetzung von Simulator- und computer-basierten Trainings für Berufskraftfahrer / Berufskraftfahrerinnen berücksichtigt werden sollte:

- Lernen ist ein sozialer Prozess, daher sollte Simulator- und computer-basiertes Training einen Austausch zwischen den Lernenden bzw. mit einem Trainer / einer Trainerin zulassen und fördern;
- Berufskraftfahrer / Berufskraftfahrerinnen sollten während des Lernens mit einem Simulator oder Computer von einem Tutor / einer Tutorin begleitet werden;
- In computer- und Simulator-basierten Trainings für Berufskraftfahrer/ Berufskraftfahrerinnen sollten die Lernziele und Lernergebnisse klar definiert sein;
- Computer- und Simulator-basiertes Training sollte die Vorkenntnisse sowie die Arbeitsrealität von Berufskraftfahrern / Berufskraftfahrerinnen berücksichtigen;
- Verknüpfung von theoretischen und praktischen Übungen in Simulator- und computer-basierten Trainings, um den Transfer der Lernergebnisse in die Praxis zu fördern;
- Train-the-Trainer, damit diese mit Computern und Simulatoren als Lernmedien umgehen können;
- Dokumentation von Lernergebnissen in Simulator- und computer-basierten Trainigs für Berufskraftfahrer / Berufskraftfahrerinnen.

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Introduction

The ICT-DRV project explores opportunities and challenges of technology-based training methods within the initial and continuous vocational training (I/CVET) of professional drivers. The major focus of the ICT-DRV project is on computer-based distance learning (CBT), and on the application of simulators (SBT) within professional drivers' vocational education and training.

Directive 2003/59/EC and the requirements of the European Qualification Framework serve as the major European reference points for the ICT-DRV project. The intention of the project is to draft quality standards, develop pilot samples, and define competence requirements of trainers for the high-quality integration of computer- and simulator-based training into the vocational education and training of professional drivers. Furthermore, the current state of technology-based training within professional drivers I/CVET is explored and policy recommendations are developed for the reasonable integration of technology-based learning into the initial and periodic training of drivers as specified by EU directive 2003/59.

Aims of work package 1

The primary aim of work package 1 (WP1) is to explore the scientific landscape of computer-based (CBT) and simulator-based training (SBT) in (vocational) education and training, and to provide an overview on relevant instructional design theories and principles that should be considered when developing CBT and SBT. The work package intends to:

- provide background information on the scientific research results to build upon when identifying limitations, options, and requirements of CBT and simulator use in professional driver training, and when developing recommendations for the application of such tools in the framework of directive 2003/59/EC (WP5);
- provide recommendations for the selection and development of pilot applications (WP3);
- provide indicators for requirements of trainers working with such tools based on scientific research (WP4);
- collect and systemise scientific resources on CBT and simulator use in professional driver training for the development of the web-platform (WP6);
- support WP6 and WP7 in their exploitation and dissemination efforts by actively involving stakeholders in the work package implementation.

Outcomes of work package 1 (deliverable 1)

The main product of the work package is the deliverable 1 report, which provides a synoptic overview of research findings with regard to the pedagogical dimension of CBT and SBT in (vocational) education and training in general, and in professional driver VET in particular. One of the central aspects tackled in this report is how the learning descriptors "competence" and "skills" can be addressed with these kinds of technology-based training tools. The end-users of this research report are scientists, CBT and SBT developers, VET providers, public authorities, and competent bodies interested in applying CBT and SBT in professional drivers' VET.

Methodological approach

In order to implement WP1 partners were initially asked to review and summarise the relevant literature on the pedagogical dimensions of CBT and SBT available in their respective countries (Austria, Finland, France, Germany, Hungary, Poland, Spain, and the UK). Furthermore, each partner was required to conduct at least two interviews with scientists/researchers working in the area of CBT and simulation and/or CBT developers, and providers of simulator training and developers of simulators. An interview guideline and a template for the literature review were developed by the work package leader (3s). Data was received for all project countries and analysed by 3s. This deliverable report was developed on the basis of these results and a literature review

Outcomes of national data gathering

The data obtained indicates that the widespread integration of technology-based learning into professional driver training is hindered by two main factors. The first is a strong level of scepticism towards technology-supported learning from the relevant actors. The second is the prevalence of legal regulations which apply an input orientation with a focus on traditional training settings. Both barriers are based on a lack of trust in technology-based training tools and their appropriate application within VET for drivers with their special needs and characteristics. The data also shows that currently no theoretical and/or pedagogical considerations are made in the development and application of simulator-based trainings (SBT) in those countries where simulators are used (Germany, Finland, France, Poland, Spain and United Kingdom). Furthermore, the learning outcomes which should be achieved by means of simulator-based training are not specified in terms of knowledge, skills, and competences. In the majority of cases the level of fidelity and ways to reduce so-called simulator sickness are the main points of interest for simulator developers and training institutes using simulators. With regard to computer-based training (CBT), the research conducted showed that some principles and concepts are established by developers and trainers when developing CBT. The majority of the experts interviewed reported that: training objectives or learning outcomes that should be acquired by means of CBT are defined before the development of CBT; that before implementation of CBT student needs are assessed; and that CBT is mostly used for problem-centred learning. One interviewee mentioned that cognitive theory is partly applied in the development of CBT. Several of the interviewed CBT and SBT experts gave recommendations on what they consider, or what should be considered, when developing CBT and SBT. They stated that one of the main challenges encountered when developing/using CBT and SBT is the question of 'how to motivate the leaner and how to enhance self-discipline and autonomy'? They suggested that a potential solution to this problem is the provision of tutorial support to learners either virtually or face to face. If this type of support is lacking student motivation and interest may decline rapidly. Moreover, the experts recommended modularisation and individualisation that allows students to either choose specific training modules or develop their own training path. Interviewees also stated that the computer- /simulator-based training resources should be made accessible online to enable students to access it whenever and wherever they want to. Another important factor to consider when developing and/or using CBT/SBT is the monitoring and assessment of the training progress of the learner (i.e. via multiple-choice questions, tests, or case studies), because this also has an impact on the motivation of the student. In general the experts consulted recommended that when didactically planning a CBT/SBT training session the underlying assumption should be that learning is a social process and that some kind of discussion/exchange with others (be it other students or the tutor) is necessary. This can be achieved either through virtual communication platforms or via phases of personal attendance (blended learning). Moreover, before developing CBT/SBT the learning goals and outcomes should be clearly defined and communicated to the students. Finally, the learning management should be flexible - the methods used should be adapted to the defined learning outcomes and learning goals.

Structure of the report

This report is structured according to a series of guiding questions designed to guide action when developing CBT/SBT in general, and driver training in particular. In the first section, *'What are CBT, blended learning and SBT?'*, a short history of CBT, blended learning, and SBT is provided and the definition of these terms as used within the ICT-DRV project is presented. The second section, *'When and how can CBT/blended learning/SBT replace and/or generate an added value to traditional classroom training?'*, presents an overview on advantages and disadvantages of the use of CBT, blended learning, and SBT rather than of traditional classroom training. The third section, *'What theoretical considerations should be made when developing CBT/ SBT?'*, examines the main learning theories relevant to CBT/SBT which are currently disregarded in the development of technology-based trainings, at least in the countries surveyed in the ICT-DRV project. Section four, *'How to plan, design and implement CBT/SBT?'*, provides a definition of instructional design and traces its history. Section five, *'What steps should be followed when designing CBT/SBT for professional driver training?'*, presents several instructional design models that might facilitate the development of CBT/SBT by trainers/developers. The final section, *'Conclusions and recommendations when applying CBT/SBT for driver training'*, summarises the findings of this report and provides recommendations on what should be considered when developing CBT/SBT for drivers on the basis of the findings of this report and the outcomes of the pilot trainings developed in WP3 of the ICT-DRV project.

1 What are CBT, Blended Learning and SBT?

This section briefly describes the history of CBT, blended learning, and SBT and presents the definitions of these terms as they are used in the frame of ICT-DRV project.

1.1 Definition of CBT in the ICT-DRV project

Computer-based training is a term used heterogeneously to refer to very different kinds of training primarily facilitated by computers or mobile computing devices. No specifications have been established for computer-based training in the framework of directive 2003/59/EC (the regulation primarily referred to in the framework of ICT-DRV). A number of European countries developed their own guidelines on computer-based training in this context, which generally limit the use of computer-based training to classroom settings. Only in a small number of cases is computer-based training outside the classroom considered an eligible form of learning in this field, usually in relation to distance learning. In the framework of ICT-DRV, the term "computer-based training" is defined as a distance and/or blended learning approach facilitated by a computer or other form of mobile computing device used for the initial and continuous VET of professional drivers. The computer or mobile computing device enables the interaction between the learner and electronic-based content (courseware/software), and/or between the learner and an-/other individual/-s (fellow learners, trainers, tutors). It can be self-paced and/or instructor-led and includes different kind of media.

1.2 Definition of Blended Learning in the ICT-DRV project

Blended learning, often also referred to as "hybrid learning", is a form of learning in which computer-based training (mainly e-learning or online learning) is supplemented by traditional classroom training. It combines the flexibility and efficiency of technology-based learning with the social aspects of face-to-face communication, and in some cases with practical learning activities. In blended learning different learning methodologies, media, and forms of learning theory are intertwined. However, it is necessary in this form of learning that the presence phases and online times are functional reconciled. Blended learning should help learners to absorb information more quickly, internalise the knowledge more effectively, and enable an expansion of individual learning content.[1]

1.3 Definition of SBT in the ICT-DRV project

Directive 2003/59/EC considers simulator-based training to be training undertaken in top-of-the range simulators. However, the Directive does not specify what the term "top-of-the-range simulator" refers to with any level of granularity. A number of European countries, however, do specify criteria which must be met by simulators in order to be considered "top-of-the-range" (countries such as, among others, France, Germany, Finland, the Netherlands, Czech Republic, and

[1] http://www.skillsoft.at/glossar/blended-learning.asp [accessed 29.10.2013].

Hungary). Such considerations are primarily based on and/or include the intended learning outcomes with the application of simulator-based training. Therefore, the term simulator-based training is, in the context of ICT-DRV project, defined as a training approach used within the initial and continuous VET of professional drivers that is supported by an artificially created realistic virtual environment that mirrors the "real world" conditions of driving. A simulator replicates the relevant external factors, conditions, scenarios, and events with which a driver interacts with sufficient realism to reach the intended learning outcomes, whilst allowing for the assessment of the driver's behaviour.

1.4 Brief history of CBT

The origins of computer-based instruction can be traced back to programmed instruction based on the behaviourist concept of operant conditioning. These initial learning programmes where based on stimulus response behaviour, followed a linear logic, and were first developed by Skinner and Holland in 1938. The so called 'instruction machines' presented learning content to users in small frames and textual form. Questions on the content followed each section. The selected answer was inserted into the instruction machine and the student received feedback on whether their answer was correct or not. As these instruction machines followed a behaviourist logic (see also section 3.1) learner feedback was particularly significant, as according to the concept of operant conditioning the learner needs to receive correct answer patterns in order to change "wrong" behaviour (Niegemann et al. 2008, p. 4). In 1959 Crowder developed the branching theory of programmed instruction with error-dependent branching. Typically, Crowder's programmes included larger frames of content followed by multiple-choice questions. When the learner selected an incorrect answer he/she received an appropriate comment, and then continued with another sequence of frames, or repeated particular sequences if they had failed to understand the content (ibid., p. 6). Crowder's work proved influential and branched programmes of instruction subsequently became the typical form of computer-based instruction as they allowed the learner a greater degree of independence. From the 1970s to the beginning of the 1980 in particular, there was great interest in computer-based instruction in Europe. This declined slightly in the early 1980s due to high development costs. In the mid 1980s the relevance of CBT increased again, especially because large companies (e.g. Siemens) identified added-value in using CBT for the in-company training of their staff (ibid., p. 15). The 1990s saw a boom of computer-based instruction accompanied by very high expectations of this form of training. As these expectations could not be met, the importance of CBT decreased again at the turn of the millennium. By this time however, computer-based instruction had become an established form of learning and training in many education institutions (ibid.).

1.5 Brief history of Blended Learning

The idea of combining learning in the classroom with learning at home is certainly not a new concept, but as technology developed it gained enhanced relevance.[2] The term 'blended learning' first appeared in a press release from EPIC Learning, a computer-based skill certification and software business based in Atlanta, Georgia, in 1999 (Friesen 2012, p. 1). Blended learning gained importance in the 1990s as it became clear that e-learning, despite experiencing a boom at this time, could not meet all of its intended objectives. Practitioners reasoned that a combination of traditional classroom training with e-learning or CBT would enhance the learning effects. Today blended learning solutions are quite common and often also include online learning.[3]

1.6 Brief history of SBT

Simulators used for training purposes were first created at the beginning of the 20th century to instruct pilots. The first highway driving simulators, however, followed much later and were initially developed in the 1950s, primarily in the United States. They first came into operation in the 1960s (Blana 1996, p.4). Insufficient technological capacity in terms of visual displays led to a reduction in efforts to develop driving simulators by the mid 1960s. By 1975, there were at least 16 driving simulators in operation in the United States, each using different techniques to generate the visual display. In contrast, at this time Europe had only two operational training simulators. The use of driving simulators for both training and research purposes has increased considerably since the 1980s. The primary reasons for this were the development of powerful computer systems (including visual displays) that became available at reduced costs, and the identified need to improve the understanding of driver behaviour under controlled experimental conditions, and thereby contribute to improving traffic safety (ibid., p. 5).

2 When and how can CBT/Blended Learning/SBT replace and/or generate an added value to traditional classroom training?

This chapter provides a general overview on the main advantages and disadvantages of using CBT, blended learning, and SBT compared to traditional classroom training. Furthermore, it reviews perspectives found in the literature with regard to the issue of under which circumstances computer-based training, simulator-based training, or blended learning approaches are more or less suitable than, or of equal value to, traditional classroom training.

[2] http://www.teachthought.com/learning/the-context-and-history-of-blended-learning/ [accessed 30.10.2013].
[3] http://www.nwlink.com/~donclark/hrd/history/blended.html [accessed 30.10.2013].

2.1 Advantages and disadvantages of CBT compared to traditional classroom training

When comparing CBT to traditional classroom training, the *accessibility* and *flexibility* of the CBT learning process – its ability to offer decentralised forms of skills acquisition - are cited as positive characteristics in the literature (cf. Prücher 2006; Vinz et al 2006; Weiß et al. 2007; Schweighofer 1992). This means that students are able to access the learning programme whenever and wherever they wish and hence have flexibility in planning and undertaking their own learning process. This is generally not possible within classroom settings as classroom training sessions are usually conducted at fixed locations and times. The *individualisation of the learning process* is another advantage of CBT, as the learner can individually regulate his/her learning process in terms of learning speed, learning pathways, and learning times. When appropriately programmed and designed the learner can, moreover, select the level of difficulty of a learning unit and decide when they require assistance. This enables learning to be adaptable to the individual conditions, prior learning, and individual learning load of a student (adaptability) (ibid.). The individualisation of the learning process is difficult to implement in a classroom setting as the tutor is usually required to facilitate the learning of a higher number of students and thus, must consider different learning styles and variances in prior knowledge. It must be noted that some authors state that the flexibility and individualisation characteristics of CBT most effectively meet the needs of adult learners and are less useful for IVET students, because the greater the freedom a learner has to choose his/her own learning path, the greater the level of personal responsibility and skill required by the learner to be successful (Schweighofer 1992, p. 65; Vinz et al. 2006, p. 7; Weiß et al. 2007, p. 31-32). The possibility for *self-assessment* in CBT, through the provision of direct feedback based on learner responses, facilitates the self-estimation of the progress made by the student (Schweighofer 1992, p. 65; Weiß 2007, p. 31-32). Furthermore, the discrete learning environment of CBT helps students with learning anxieties (e.g. those caused by previous unsuccessful learning experiences) as the social embarrassment which may accompany failure in a classroom setting is removed from the process. Moreover, the subjective influence of the trainer is diminished by CBT (Schweighofer 1992, p. 66). Another advantage of CBT cited by some authors is its *scalability,* as it makes it possible for increased class sizes to learn with fewer resources. Hence, classroom limitations do not apply and modern learning management systems allow for the management of learning outcomes of larger numbers of students (Vinz et al. 2006, p. 7-8; Schweighofer 1992, p. 67). *Central development* and *central up-date* of CBT content whenever necessary are other advantages, particularly where CBT programmes are available online (Vinz et al. 2006, p. 8). While the use of CBT in learning processes can clearly confer a number of advantages, there are also disadvantages to its utilisation. A *lack of computer literacy* and *limited access to technology* among some groups of learners might hinder CBT's effectiveness as learners are required to master computer-based training environments in order to succeed. The number of people for whom this is problematic is decreasing over time, but still represents a challenge for some groups of learners (Vinz et al. 2006, p.8-9; Horz 2004, p. 12-13). Another disadvantage cited in literature is the *lack of learning adaption* to the personal background experience and/or prior knowledge of the learner in comparison to traditional forms of learning where the teacher is able to exercise their professional judgement on the extent of a learners' prior knowledge (Schweighofer 1992, p. 69). However, this primarily applies to CBT programmes which are badly designed, as typically learner needs are assessed before the development of a computer-based learning programme begins. As learning is mostly defined as a social process, the *lack of social interaction* – sometimes also termed as "social loafing" (Koller et al. 2006, p. 8-9) – inherent in CBT is identified as another disadvantage of this approach, as the level of effort made by learners in relation to their studies may reduce when he/she perceives that doing so will have no negative social consequences. Furthermore, the lack of personal contact with instructor and peers encourages the perception amongst learners that they are not being monitored (ibid.; Schweighofer 1992, p. 70). This is cited as one of the reasons why *drop-out rates* may be higher in CBT than in classroom training (Koller et al. 2006, p. 9). Another factor to be considered when applying CBT is that computers do not have an *associative thinking ability*, and therefore have no way to determine whether learning content is understood by the learner, nor any capacity for identifying the possible causes of incorrect answers. Tutors in face to face training on the other hand, do have this ability, and can assess students individually (Schweighofer 1992, p. 70). The fact that learning in an artificial environment requires *parsing the learning content* into logical units, which may lead to compartmentalisation and the student losing perspective on the 'big picture' context, is also cited as a possible disadvantage of the use of CBT (ibid., p. 71). This effect could also occur, however, in modularised classroom courses. Though computers have been used for training purposes since at least the 1980s, CBT still suffers from a *lack of credibility* when compared to traditional degree programmes (Vinz et al., p. 10). Moreover, well designed CBT programmes usually have *high upfront development costs*, which can require significant investment, although over time at least some of this investment will be repaid by the ability it provides to train more people with fewer resources (ibid., p. 11).

2.2 Advantages and disadvantages of blended learning compared to traditional classroom training

Some of the advantages and disadvantages of CBT can be mitigated through the application of blended learning approaches, where computer-based training is combined with traditional face-to-face classroom activities. For example the *individualisation of the learning process* offered by pure CBT might provide added value for some groups of learners (e.g. adult learners), whereas blended learning options might be more suitable for other groups (e.g. IVET students), particularly those that are not used to independently organising their learning process, learning speed, etc. Blended learning may also increase *scalability* as operating increased class sizes with fewer trainer resources is possible because the trainer acts more as a facilitator than a teacher in the traditional sense. Furthermore, the *lack of social interaction* in CBT might be compensated for by the use of blended learning arrangements as the classroom sessions provide both teachers and students opportunities to interact with each other. Teachers are able to teach, observe, evaluate, and provide feedback to the students during the classroom sessions, while students have opportunities to ask questions, or request additional explanation. Moreover, students are able to learn and share their knowledge and experiences with their peers, which enables them to develop not only their cognitive but also their affective and psycho-motor abilities.[4] Additionally, teachers have more flexibility in delivering learning materials and administering assessment (i.e. via online task submission, quizzes, or final exams) with students able to finish their tasks wherever they are geographically(ibid.). The combination of computer-based training with classroom units may also result in a decrease in dropout rates as missing social interactions with pure CBT can be mitigated during classroom sessions. Furthermore, a *lack of computer literacy* can be compensated for by blended learning arrangements as an instructor can introduce the learner to the programme, its functionality, and operation. Another disadvantage that might be mitigated through the application of blended learning is the inability of computers to exercise an *associative thinking ability*, as an instructor is able to monitor/assess the learners.

2.3 Advantages and disadvantages of SBT compared to learning in real or classroom settings

In comparison to driver training in actual vehicles and in real traffic, driving simulation has several advantages and benefits for the drivers as it allows learners to experience specific driving situations which may be difficult or impossible to replicate consistently in the real world (Beckers 2013, p. 13). It must be noted, however, that simulators can only ever provide a representation of reality and can never fully compensate for real world experience (Kappe 2013). SBT might increase the *quality and efficiency of training* due to the high intensity of the training (ibid.) and may *improve driving skills* in risky situations (Ucińska 2010, p. 104). Furthermore, driving simulation is *environmentally friendly* and can be used to teach eco-driving (ibid.). *Lower staff costs*, an *optimisation of training costs,* and the *longer lifetime of simulators* in comparison to real vehicles are other advantages cited in the literature (ibid.). The use of a driving simulator also enables trainees to be exposed to *wide variety of traffic situations* and to *repeat scenarios* that they experience difficulty in. For example, driving in *different weather situations* (i.e. fog, rain, snow), *different road environments* (i.e. city, village,

[4] http://yudinugroho.wordpress.com/2013/07/04/the-advantages-and-disadvantages-of-blended-learning-in-language-teaching-2/ [accessed 29.10.2013].

motorway, country or mountain roads), and *driving in day or night time* are areas of training which simulators can replicate with ease (ibid., p. 105). *Computerised and objective assessment* (evaluation by the programme and/or the trainer), and *feedback from different perspectives* (i.e. helicopter perspective) are also cited as advantages of SBT in the literature (ibid.). Furthermore, *the possibility to control the type and timing of training events*, to have *more possibilities for adapting the training tasks* to the performance of the trainee(s), to have *more possibilities to register and diagnose trainee performance* (i.e. for debriefing and/or administrative purposes), and to have *more possibilities for automating the process of training and instruction* and, consequently, for *improving efficiency,* are additional advantages of SBT cited in the literature (van Emmerik et al. 1997, p. 7-8). Additionally, group training allows participants to learn from one another and receive detailed feedback on their performance via an instructor debriefing (Beckers 2013, p. 13). The disadvantages of SBT most frequently mentioned in the literature are the *high development costs* of simulators, and the problem of *simulator sickness*. Other disadvantages emerge when the simulator training is *not based on a learning cycle or defined learning outcomes,* as learners may perceive the training as a game rather than a serious unit of training. Therefore, instructional planning and a trainer/tutor is essential for SBT to be effective as learning outcomes must be defined and feedback provided to the trainee during and after a training session. Another disadvantage is the problem of *transferring the acquired skills* in the simulator adequately to real life conditions (ibid.).

2.4 Comparing technology-based instruction with traditional classroom training

The previous section provided an overview of the general advantages and disadvantages of the use of CBT/SBT in comparison to traditional classroom training, as discussed in the literature. Aside from these rather general statements, it is undisputable that the intended learning objectives and their associated learning outcomes have a major impact on the decision as to the most appropriate kind of learning environment. This section addresses the empirical evidence with regard to the circumstances in which CBT, blended learning, and simulator-based training approaches are more or less suitable than, or of equal value to, traditional classroom training. One way of approaching this issue is to begin by examining the intended learning objectives and associated learning outcomes of a training programme. Therefore, in the following section the learning outcomes and objectives for which CBT, blended learning, and SBT are especially suitable are discussed. Furthermore, the outcomes of empirical studies dealing with the effectiveness of CBT, blended learning, and SBT in comparison to traditional classroom training are examined.

2.4.1 Comparing CBT with traditional classroom training

A study that investigated the effects of several course design characteristics by screening different studies on the effectiveness of CBT in comparison to classroom training concluded that: *'the relative* *effectiveness of training may depend on both the intended learning outcomes and the training conditions'* (Sitzmann et al. 2006, p. 648). Learning objectives or learning outcomes describe the necessary learning activities (or rather the desired learning behaviour), specify the conditions under which learning is performed, and determine the criteria for measuring the learner's achievements (Schweighofer 1992, p. 42ff). Generally, learning objectives can be distinguished between cognitive (knowledge, assessment ability), pragmatic (skills), and affective (attitudes) learning objectives (Pfleger 2004, p. 41). Referring to these three general categories Gagné differentiated five categories of learning outcomes: intellectual skills (procedural knowledge); cognitive strategies (the learner controls their own learning process, transfer of what is learned to other situations); verbal information (declarative knowledge); attitudes (affective area); and motoric skills (see also section 5.3) (ibid., p. 43). Technology-based learning is typically associated with an improvement of knowledge, skills and behaviour, rather than a change of behaviour (Ebner et al. 2011, p. 4). Therefore, CBT is particularly suitable for cognitive learning goals such as acquiring, keeping, recalling, extending, applying, and transferring knowledge (i.e. knowledge or information recall, comprehension or conceptual understanding, the ability to apply knowledge, the ability to analyse a situation, the ability to synthesise information from a given situation, and the ability to evaluate a given situation) (Schweighofer 1992, 42ff). A meta-analysis that examined over 200 empirical studies comparing the effectiveness of learning the same content through traditional classroom training settings and via computer-based training, for example, showed that learning was more effective when the information was conveyed with the use of multimedia (i.e. text, graphics, animation, pictures, video, sound, etc. or a combination of these) (Najjar 1996, p. 129) than when training relied on traditional classroom lectures alone. Furthermore, the study also demonstrated that often learning was quicker with computer-based training in comparison to traditional classroom lectures (Najjar 1996, p. 2). These advantages were attributed primarily to the fact that '*computer-based instruction may force the instructional designer to better organise and structure the learning material compared to traditional classroom lecture'* (ibid.). Another factor identified in the study was the positive impact of the interactivity of computer-based instruction on learning. In comparison to those learners who participated only in classroom lectures, those individuals who utilised computer-based instruction learned the material more quickly and had better attitudes towards the learning process (ibid.). The study did state, however that this difference could be due to the fact that using CBT is generally more interactive than classroom training, and that this may have had an impact *'rather than the multimedia information itself'* (ibid., p. 3). Evidence from cognitive psychology indicates that CBT offers advantages in promoting learning retention and leads to effective learning delivery as the student learns at his/her own pace, with technically correct and consistent training methods (Vinz et al. 2006, p. 8). In summarising its examination of empirical studies dealing with the effectiveness of

CBT compared to traditional classroom training, the study concluded that computer-based instruction *'may help people to learn more information in less time than traditional classroom lectures'* (Najjar 1996, p. 10)

2.4.2 Comparing blended learning with traditional classroom training

A combination of computer-based and classroom training may be the most suitable approach for achieving affective learning objectives which intend to change attitudes, appreciations, or relationships. Furthermore, a study that investigated the impact of blended learning in comparison to traditional classroom learning showed that a blended learning environment may increase learning by an average of 11% for both procedural and declarative knowledge (Sitzmann & Ely 2009).[5] However, the study also indicated that drop-out rates in e-learning may be as high as 20%, as a lack of personal contact between the student and their instructor and peers fosters the impression that the learner is not being monitored, and this consequently impacts their commitment. The inclusion of a blended learning component that facilitates social interaction with an instructor and peers may lead to a reduction in drop-out rates. Osguthorpe and Graham (2003) identified six advantages of the use of a blended learning system: (1) pedagogical richness; (2) access to knowledge; (3) social interaction; (4) personal agency; (5) cost effectiveness; and (6) ease of revision (Graham 2004, p. 7). A study conducted by Robles (2012) that investigated the effect of blended learning approaches on student performance (Robles 2012, p. 1) indicated that those students who did not participate in a blended learning course showed no serious improvement, whereas students in a blended learning group demonstrated a significant increase in performance (ibid., p. 7). A common refrain in the literature is that blended learning offers the "best of both worlds", and that *'blended learning has a higher acceptance and a higher perceived value (closer to face-to-face learning) than online courses'* (Allen, Seaman & Garett 2007, p. 2).

2.4.5 Comparing SBT with traditional training

In order to acquire pragmatic learning objectives or motoric skills it is necessary to practice those skills repeatedly. Simulator-based training, therefore, appears to be a promising approach for learning objectives and associated learning outcomes where this is the focus (e.g. used to practice driving in snowy conditions in a secure environment). Simulation offers several benefits as a training medium. It allows the learner to receive training in a realistic environment that includes contextual characteristics. Simulators can *'be used as realistic practice environments that are too dangerous to be trained in the real world and offer opportunities to practice tasks that occur infrequently or to repeat tasks'* (Bell, Kanar & Kozlowski 2008, p. 4-5). Empirical studies indicate that this type of training is most successful when training sessions are structured along pre-defined learning

[5] http://www.nwlink.com/~donclark/hrd/history/blended.html [accessed 30.10.2013].

objectives/learning outcomes, where there is *'subsequent analysis of, and reflection on the experience'* of the training in the simulator *'aiming to facilitate incorporation of the changes in practice'* (briefing and debriefing) (Fanning/Gaba 2007, p. 115-116), and when training is divided into sessions with a maximum duration of 30 minutes (Beckers 2013, p. 6). Furthermore, SBT is considered particularly suitable for professional learning. For SBT learning to be effective, it is essential that a facilitator accompanies the simulator training process and that the trainee is debriefed following each session (ibid., p. 116). Any consideration of SBT must recognise that there are a variety of different simulators in place which are applicable to different learning objectives/outcomes and broadly suitable for the purpose of fulfilling these learning outcomes. When considering the specifications made in Directive 2003/59/EC, the only reference made to simulators is to the use of a "top-of-the-range" simulator. The Directive does not provide a definition for 'top-of-the-range'. Representatives of some countries that use simulators for driver training in the framework of Directive 2003/59/EC, and that participated in the ICT-DRV project, stated that use of top-of-the-range simulators was unnecessary to achieve some of the learning objectives defined in the Directive.

3 What theoretical considerations should be made when developing CBT/SBT and why?

There is an indisputable relationship between instructional theory and the dependent multimedia-based technologies, but often this connection is insufficiently considered in the development CBT and SBT. Many authors state that designed instruction should be grounded in learning theory (Cooper 1993, p. 12), as technology-media based instruction should enable learners to acquire targeted skills and competences. Hence, these programmes should be designed on the basis of a theoretical framework which is dependent on the intended learning goals and outcomes (ibid., p. 14). Therefore, in this section the three main theories of learning, and their potential application to CBT and SBT, are discussed.

3.1 Behaviourism

In behaviourism the learner is assumed to be essentially passive and learns through response to external stimuli. Learning is defined as change in behaviour. In behaviourism the environment is the most important factor in shaping human behaviour: through reinforcement the consequences of our actions affect subsequent behaviour (Cooper 1993, p. 12). In the behaviourist conception the learner begins as a "tabula rasa" or "blank sheet" and their behaviour is shaped through positive or negative reinforcement applied through reward and punishment.[6]

B. F. Skinner's approach is particularly relevant for technology-based learning. He differentiates between two forms of behaviour: "respondent behaviour", behaviour that occurs in response to stimuli and is characterised by involuntary action (i.e. moving back when being attacked); and 'operant behaviour', referring to behaviour that is influenced by consequences (Schweighofer 1992, p. 34-41). An individual learns through repetition, imitation, and training of presented processes and learning is regulated by reward and punishment, the assumption being that that positive and negative reinforcement influences the probability that antecedent behaviour will reoccur. Therefore, in this approach, punishment (negative reinforcement) decreases the likelihood that antecedent behaviour will be repeated. In this context positive refers to the application of a stimulus and negative to the withholding a stimulus.[7] According to Skinner, the successful acquisition of complex behaviour through programmed instruction requires the learning goals to be defined in a clear and objective manner: the learning content should be constructed in sequences of manageable learning steps; and the sequences should be precisely prescribed and controlled by the instruction machine.[8] This type of learning programme is also referred to as linear program structure (Schweighofer 1992, p. 34-41). Furthermore, in behaviourism the learning tasks should be constructed in such a way that learners are likely to successfully complete them, and that feedback on students' answers follows immediately after completion. Thinking of a classroom setting teachers must enhance a certain stimulus and continuously vary between reward and punishment in order to initiate the learning process and support successful learning (change of behaviour). The lessons are ideally sequenced and based on each other. The difficulty of the learning tasks should be continually increased to challenge the learner and demonstrate their learning progress.[9] At the beginning of each training session the learners should be informed about the expected learning outcomes. In this way, learners can compare their expectations with their self-perceived learning successes. The acquired knowledge should be assessed in order to validate the learning progress.[10]

Computer- and simulator-based training that follows a behaviourist conception is useful for imparting facts (i.e. vocabulary), procedural learning (i.e. how to use a machine), or the automation of reactions (i.e. in driver training) (Aachen University 2007, p. 1). Chase (1985) argued that *'[...] the application of behaviourist principles leads to a reductionist and fragmented program, which concentrates on low-level skills at the expense of "complex, conceptual behaviour"'* (Cooper 1993, p.

[6] http://www.learning-theories.com/behaviorism.html [accessed 14.08.2013].
[7] http://www.learning-theories.com/behaviorism.html [accessed 14.08.2013].
[8] http://e-learning.typepad.com/elearning/2005/05/behaviorismus.html [accessed 14.08.2013].
[9] http://e-learning.typepad.com/elearning/2005/05/behaviorismus.html [accessed 14.08.2013].
[10] http://e-learning.typepad.com/elearning/2005/05/behaviorismus.html [accessed 14.08.2013].

13), but he tempered this critique when he stated that the focus of criticism should be on *'[...] poorly developed software rather than the underlying theoretical approach'* (ibid.).

3.2 Cognitivism

In contrast to behaviourism, cognitivism focuses on the internal processes of learning and the cognitive structures of the brain. In cognitivism, human behaviour is assumed to be more than a stimulus-response-chain and reactions are only partially controlled externally (Stangl).[11] It is assumed that to understand how people learn the "black box" of the human mind must be opened.[12] Mental processes such as thinking, memory, knowing, and problem-solving need to be explored. The main areas of cognition are sensory, receptors, executive control, working memory, and long-term memory (Cooper 1993, p. 14). In cognitive theory knowledge can be seen as schema or symbolic mental constructions. Learning in cognitive theory is therefore defined as a change in learners' schemata.[13] It is viewed as an information processing operation and the dynamic nature of knowledge acquisition is emphasized. Hence, the learner has to internalise the information received and compare it with their pre-existing knowledge. In this process, the learner will determine the relevant information in order to generate rules.[14] New information is always processed with respect to existing knowledge and the learning process is influenced by the targeted aims and expectations of where and how the new knowledge can be used (Schweighofer 1992, p. 34-41). *'Central to the notion of cognitive analysis is a model of the internal workings of the mind, the identification of functional components to handle information filtering, storage in short-term memory, semantic encoding for storage in log-term memory, and retrieval when required'* (Cooper 1993, p. 14). Therefore, learning in the cognitive sense requires, 'the complexity of the learners' actions […] to be matched by a similar level of complexity in the instructor's actions' (ibid.). Cognitive learning strategies are primarily used to develop and strengthen problem solving capacities. Hence, the goal of cognitive instruction *'should be to replicate the knowledge structures and processes of the expert/instructor in the mind of the learner'* (Cooper 1993, p. 15).

Computer- and simulator-based instruction programmed in a cognitive sense should offer a high degree of freedom of choice of the learning path, and the preferred learning method should encourage the natural curiosity of the learner while responding to individual interests and desires.[15] Thus, such learning arrangements require didactical/instructional design models that are tailored to

[11] Werner Stangl's Arbeitsblätter: Die kognitive Lerntheorie. Online: http://arbeitsblaetter.stangl-taller.at/LERNEN/LerntheorienKognitive.shtml [accessed 26.08.2013].
[12] http://www.learning-theories.com/cognitivism.html [accessed 14.08.2013].
[13] http://www.learning-theories.com/cognitivism.html [accessed 14.08.2013].
[14] http://e-learning.typepad.com/elearning/2005/05/kognitivismus_.html [accessed 14.08.2013].
[15] http://e-learning.typepad.com/elearning/2005/05/kognitivismus_.html [accessed 14.08.2013].

the needs of specific target groups (Aachen University 2007, p. 1) and are able to capture more data than just learner responses (Cooper 1993, p. 15).

Excursus: Cognitive Load Theory

Cognitive Load Theory is closely linked to cognitive theory and is especially relevant for CBT and SBT. It addresses: *'how to deal with the limited capacities of our brain most effectively'*; *'how to distinguish necessary and unnecessary load in learning:'* and *'how to avoid unnecessary loads'*. The focus of the cognitive load theory, therefore, is the relationship between the instructional design of the learning offer and the design features of human cognitive architecture. Proponents of Cognitive Load Theory compare human short-term memory with the memory of a computer which has a limited capacity. A multimedia-based training programme – which is currently the most significant area in which this theory is applied – should not exert an unnecessary load on the limited resources of the mind so it is able to also perform the desired memory operations. In the current conceptualisation of Cognitive Load Theory, cognitive load is comprised of three components: learning-related stress, extrinsic stress, and intrinsic stress. These three components correspond with three types of cognitive load: the intrinsic load, the extraneous load, and the germane load. The germane or learning-related load is directly connected with learning, and refers to the effort a learner must expend to understand the learning material and to build cognitive schemata. Germane load increases and supports learning and is influenced by the presentation of the learning material. The unnecessary, extraneous load detracts from the desired learning. This load occurs, if, for example, a large amount of energy is expended to find the necessary information in a learning offer. Furthermore, the extraneous load is influenced by the presentation of the learning material. When intrinsic load, related to the learning material itself, is added to the mix, it is possible to gain a more complete understanding of the nature of cognitive load. The more difficult the learning material is the higher is the intrinsic stress. For example, the more individual learning elements are interrelated, the more difficult the learning material is, the higher the intrinsic stress will be. It is not possible to influence the intrinsic load, because this element of cognitive load is determined by the learning material itself. Generally speaking the cognitive load should not exceed the capacity of the short term memory, because if it does the mind becomes overloaded and nothing is learned (Stangl).[16] Cognitive Load Theory is suitable for making assumptions about when learning outcomes can be expected to be achieved in complex learning environments (i.e. computer- or simulator-based learning). It allows one to make statements on the relationship between the cognitive resources of the working memory of a learner and the learning environment necessary for processing a cognitive performance (ibid.).

[16] Stangl, Werner. Arbeitsblätter, Cognitive Load Theory. http://arbeitsblaetter.stangl-taller.at/LERNEN/CognitiveLoad.shtml [accessed 26.08.2013].

3.3 Constructivism

Constructivism states that learning is an active, contextualized process of constructing knowledge rather than a process of acquisition. In constructivism the learner is placed at the centre and knowledge is assumed to be a construct based on the personal experiences of the learner and the assumptions they make about the environment. Hence, constructivists perceive reality to be personally constructed and determined by personal experience (Cooper 1993, p. 16). Constructivism assumes that each person has a different interpretation of, and construction process for, knowledge. The learner is not a "tabula rasa" or "blank sheet", but instead brings previous experience and cultural factors to a situation. In constructivist learning theory a learning process is always embedded in a social environment, and thus learning is perceived as a social process.[17] Constructivist learning aims to transfer and apply acquired knowledge in practical situations. Learning is defined as a problem solving activity based on the personal discovery and intrinsic motivation of the learner (ibid., p. 17). According to the constructivist learning theory, the teacher should firstly acknowledge the learners' prior knowledge, and autonomy and initiative should be accepted and encouraged.[18] The goal is to design requirements in such a way that they are accepted by the learners as interesting and challenging. Problems should be formulated with open solutions to enable individual interpretation and the application of problem-solving strategies. Moreover, learners should be able to approach a problem collectively and from many different perspectives. The biographies of individual learners should be used to process the task in order to combine the different skills and the collective knowledge. The learners should be explicitly encouraged to continuously share their own opinions and the opinions of other learning group participants.[19] As the ability of the learner to independently monitor and control his/her own learning has a decisive role in the success of learning, constructivist learning environments should demonstrate the social significance and functional utility of the teaching content for the learner. In constructivism *'the role of the instructor changes from 'sage on the stage' to 'guide on the side'*.[20]

3.4 Conclusions

When reflecting on the relevance of the three main learning theories in terms of their application in CBT/SBT, a distinction can be made between assumptions made in objectivist theories (behaviourism and cognitivism) and constructivism. Objectivists view reality as *external to the knower* with the mind acting as input processor of reality, whereas constructivists perceive reality as *determined by the experiences of the knower* (Cooper 1993, p. 16). Therefore, *'the move from behaviourism through*

[17] http://www.learning-theories.com/constructivism.html [accessed 14.08.2013].
[18] http://www.ndt-ed.org/TeachingResources/ClassroomTips/Constructivist%20_Learning.htm [accessed 14.08.2013].
[19] http://e-learning.typepad.com/elearning/2005/05/behaviorismus.html [accessed 14.08.2013].
[20] http://e-learning.typepad.com/elearning/2005/05/konstruktivismu.html [accessed 14.08.2013].

cognitivism to constructivism represents shifts in emphasis away from an external view to an internal view' (ibid.). In behaviourism internal processes are of no interest, while in cognitivism internal processing is relevant *'to the extent to which it explains how external reality is understood'* (ibid.). In constructivism, however, internal processes are essential, as the mind is viewed as *'a builder of symbols'* (ibid.). When developing CBT/SBT one should first ask 'what should be achieved by the learner?' Technology-based learning programmes operating within the theoretical framework of behaviourism will follow a linear programme structure where learning content is divided into sequences that build on one another. Using a cognitive framework CBT/SBT should lead to external, observable actions, and therefore cognitive CBT/SBT programmes should utilise databases, hypermedia, or expert systems where the computer allows access to global education resources (Cooper 1993, p. 17). In a constructivist CBT/SBT environment the learner should be able to explore the content, interactively query a database, explore a model of reality via simulation, or interact with the application (ibid.). Therefore it can be concluded that the programming paradigm runs parallel to the theoretical framework applied (ibid.).

4 How to plan, design and implement CBT / SBT?

As indicated in the previous section, when developing CBT/SBT different theoretical aspects should be considered according to the intended learning outcomes that should be achieved by the learner. Aside from the theoretical framework, the way in which instruction is planned, organised, and implemented – often referred to as Didactical Planning or Instructional Design - also plays a major role in successful learning (Zierer/Seel 2012, p. 1). Instructional Design refers to the systematic and professional provision of education and training and is closely linked to instructional technology *'which is generally defined as systematic application of theoretically and practically established knowledge to the development of learning systems'* (ibid., p. 2). Instructional Design refers to the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the entire process of the analysis of learning needs and goals (or definition of learning outcomes) and the development of a delivery system to meet those needs. Instructional Design includes the development of learner-centred instructional materials and activities, piloting, and evaluation of all instruction and learner activities (Varley 2005). *'Instructional technology is the systemic and systematic application of strategies and techniques derived from behavioural, cognitive, and constructivist theories to the solution of instructional problems'*.[21] Gagné is commonly credited as the founder of Instructional Design as a scientific discipline. He stated that efficient instructional learning processes can only be expected when internal (the attributes of the learner) and external (the characteristics of the subject to be taught and the learning environment)

[21] http://www.umich.edu/~ed626/define.html [accessed 28.08.2013].

conditions are considered. Different learning approaches and theoretical concepts should be applied for different categories of teaching subject (i.e. learning facts, learning concepts, problem-solving, etc.) and different characteristics of the learner (i.e. prior knowledge, motivation) (Niegemann 2013, p. 3).

There are three crucial questions that instructional designers must consider to facilitate learning:

- What do I want students to be able to do?
- How should I teach it?
- How will I know if they are able to do it?

Different instructional design models have been developed to answer these questions - the challenge for course developers is determining which models are the most useful in which conditions. In general *'Instructional Design models agree on the assumption that learning can be classified in accordance with similar cognitive operations and processes (i.e., "internal conditions of learning") and can be facilitated by similar instructional methods and strategies (i.e., "external conditions of learning")'* (Zierer/Seel 2012, p. 4). A variety of instructional design models are available to course designers. In the following section those that are the most relevant for the ICT-DRV project are discussed in detail.

Excursus: ADDIE model

One basic model that encapsulates the most important principles of Instructional Design is ADDIE. ADDIE is a comprehensive framework widely used in Instructional Systems Design (ISD) (Zierer/Seel 2012, p. 9) which is *'a formal process for designing training, be it computer-based or traditional instructor-led training. The ISD process includes analysis, design, development, implementation, and evaluation.* [It is] [a]*slo known as System Approach to Training (SAT)'*.[22] The origins of ADDIE are unclear, but *'most theorists agree that ADDIE is an acronym that covers the major processes of the generic Instructional Systems Development process:* ***A****nalysis,* ***D****esign,* ***D****evelopment,* ***I****mplementation, and* ***E****valuation'* (Zierer/Seel 2012, p. 10).

1. *Analysis phase*: In the first phase a needs analysis is conducted at different levels of application (i.e. an analysis of the learning objectives, learning outcomes, and performances; an analysis of the students, the tasks, and the cost-benefit ratio of the planned instruction) (ibid.).
2. *Design phase*: In this phase a blueprint of the outcomes of instruction is designed and the entire structure of the instructional intervention or learning environment is defined. At the heart of this phase is the planning of instruction and necessary decisions on the external

[22] http://www.instructionaldesigncentral.com/htm/IDC_instructionaldesigndefinitions.htm [accessed 28.08.2013].

conditions of learning (i.e. methods of instruction, social interactions, media, organisation of the environment) (ibid.).

3. *Development phase*: In this phase the decisions made in the design phase are realised and the concrete learning material is produced (ibid.).
4. *Implementation phase*: In this phase the planned instruction is implemented in a real setting. Often the implementation phase occurs under controlled conditions and critical examination, and is closely associated with formative evaluation during the development phase (ibid.).
5. *Evaluation phase*: In this phase the success of instruction is tested and the extent to which the instructional intervention had an impact on the learner in terms of the predefined learning objectives / learning outcomes is measured (ibid.)

Critiques of the ADDIE model argue that while it may be useful for the implementation of static content, it is insufficient for learning outcomes that do not have a predetermined end state (i.e. complex problem solving) (ibid.). However, the ADDIE model has inspired a number of spin-offs or variations, some which are described in the following chapter (Zierer/Seel 2012, p. 10).

5 What steps should be followed when designing CBT/SBT for professional drivers?

The formulation of learning objectives and learning outcomes (as discussed in section 2.2) is even more important in the creation of technology based learning environment than it is in the development of conventional courses. The learning objectives determine the methodological design of CBT/SBT. The following subsections present several instructional design models that are the most applicable to the development of CBT/SBT for professional drivers.

5.1 Instructional design model by Robert Gagnés

Robert Gagnés is commonly referred to as the founder of Instructional Design. *'He believed that events in the environment influence the learning process'* (ICELS).[23] Gagnés argued that there are several different human capabilities that are learned, which are defined as behavioural changes or learning outcomes of a learner. He defined five categories of learning outcome:

- intellectual skills ("knowing how" or having procedural knowledge);
- verbal information (being able to state ideas, "knowing that", or having declarative knowledge);

[23] ICELS. Robert Gagne's Five Categories of Learning Outcomes and the Nine Events of Instruction. Online: http://www.icels-educators-for-learning.ca/index.php?option=com_content&view=article&id=54&Itemid=73 [accessed 28.08.2013].

- o cognitive strategies (possessing certain techniques of thinking, ways of analysing problems, and approaches to solving problems);
- o motor skills (executing movements in a number of organised motor acts such as playing sports or driving a car);
- o attitudes (mental states that influence the choices of personal actions).

Furthermore, he distinguished between internal and external learning conditions. Internal conditions refer to the capabilities a learner already possesses before new learning begins. External conditions refer to different stimuli extrinsic to the learner such as the environment, the teacher, or the learning content. *'This means that each new learning situation begins from a different point of prior learning and will consist of a different external situation, depending on the learner and on the learning environment'* (ibid.). Robert Gagnés defined nine events of instruction which are the external events that facilitate learning and are required to achieve each of the five learning outcomes described above (ibid.). Gagnés system is a behaviourist model that also draws from cognitivism.[24]

1. *Gaining Attention*: Functions to obtain the students' attention so they are alert for the reception of stimuli (content).
2. *Informing learners of objectives (learning outcomes)*: Inform the learner about the purpose and expected outcomes of learning (motivation of the learner).
3. *Stimulating recall of prior learning*: Allow learners to build on prior knowledge.
4. *Presenting the content*: Utilise a variety of methods (i.e. lecture, readings, activities, projects, multimedia, etc.) depending on the intended learning outcome.
5. *Providing "learning guidance":* Provide students with instructions on how to learn (i.e. guided activities, concrete examples of abstract terms and concepts, elaboration of ideas).
6. *Eliciting performance (practice):* Students apply the newly acquired knowledge and skills.
7. *Providing feedback*: Students receive feedback on individualised tasks in order to reinforce the newly acquired knowledge and skills.
8. *Assessing performance*: Assessment to verify that learning has occurred.
9. *Enhancing retention and transfer to the job*: Retention of the learned capability over a long period of time and transferring it into new situations outside of the learning environment.[25]

Gagnés nine events of instruction provide a framework for planning, conducting, and evaluating CBT/SBT, although all events may not necessarily have to be considered and/or might be combined. The final determination as to which events of instruction are required should be made by the

[24] http://edutechwiki.unige.ch/en/Nine_events_of_instruction [accessed 10.02.2014].
[25] For points 1 to 9 see http://www.icels-educators-for-learning.ca/index.php?option=com_content&view=article&id=54&Itemid=73 [accessed 28.08.2013].and http://citt.ufl.edu/tools/gagnes-9-events-of-instruction [accessed 10.07.2013].

instructor/developer of CBT/SBT after consideration of the subject, course format, course goals, needs and capabilities of the students, his or her own personal style, and technological capacities.[26]

5.2 DO-ID Model (Decision Oriented Instructional Design Model)

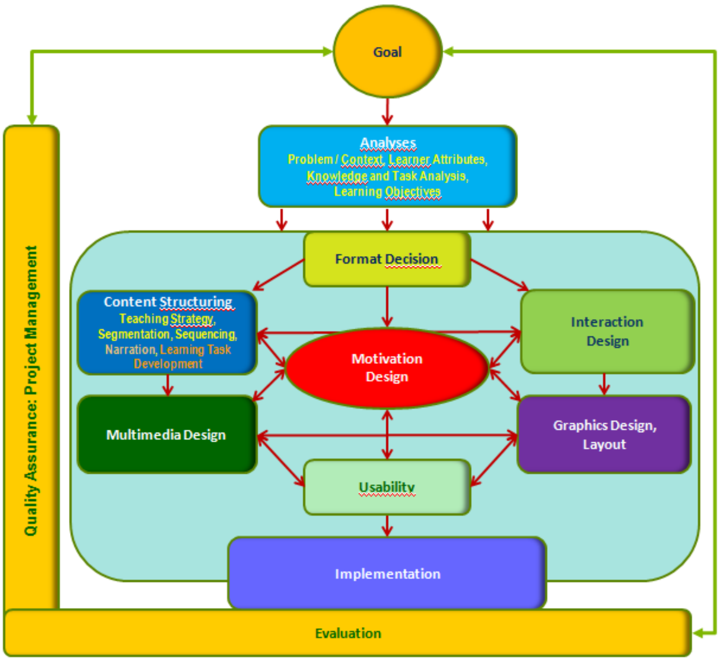
The Decision Oriented Instructional Design (DO-ID) Model developed by Niegemann et al. (2008) is one of most detailed Instructional Design models available at the time of writing (Zierer/Seel 2012, p. 10). In the systematic conception of technology-based learning a series of decisions shape the actions of instructional designers. Without systematisation and structuring of individual choices and decision-making levels the sequence of design decisions remain arbitrary. The DO-ID model was developed to provide a basis for systematic design of multimedia-based learning environments, serving as a framework for the design process (Niegemann et al. 2008, p. 83). The fundamental stages of the DO-ID model are (see also figure 1):

1. *Analysis:* Decisions require information based on facts. Therefore, the goals and learning outcomes of instruction, the learning requirements of the target group, the available resources (in terms of time, budget, and human resources), and the context, especially the relevant psychological aspects of the learning content and learning tasks (knowledge and task analysis), have to be analysed.
2. *Formats:* The decision on which format to use is one with significant consequences. Depending on the results of the initial analysis stage an e-compendium, a series of e-lectures, an educational game, or simulation might be most appropriate.
3. *Content Structuring:* The structuring of the learning content includes the consideration of several aspects: the level of abstraction (overview or consolidation); whether to facilitate deductive or inductive presentation of the content; the segmentation of the content; the sequencing of the content; and how this can be achieved in an adaptive manner (i.e. to take account of prior knowledge). If game-based formats are selected the narrative embedding of the learning content into a storyline must also be considered.
4. *Multimedia Design:* Consideration must be given to how the multimedia learning content is designed. Designers must examine how they wish to use text (spoken or written) and images (static or dynamic) and which characteristics of text and images are the most appropriate in order to achieve the intended learning outcomes of the target group.
5. *Interaction Design:* Interaction between the learner and the media significantly influences the efficiency of the learning. The media utilised should enable the kind of interaction which initiates the intended learning processes.

[26] http://deoracle.org/online-pedagogy/teaching-strategies/an-overview-of-robert-gagnes-nine-events-of-instruction.html [accessed 30.08.2013].

6. *Motivation Design:* The motivation to engage with a subject and to maintain this motivation, and the basic needs of learning, are relevant to design decisions.
7. *Layout, ergonomics, and usability:* Alongside aesthetic considerations, usability is a crucial factor in design decisions on the layout of didactical media. Inadequate usability may have a negative impact on cognitive load and hence, hinder the learning process. A usability test is indispensable when developing didactical media.
8. *Implementation:* How the media will be implemented should be considered before and throughout its development. This requires consideration of the context of application and acceptability by the target group.
9. *Quality Control:* Efficient project management, which disposes specific competences in the area of psychological-didactical quality criteria, significantly impacts on the quality of a didactical media product.[27]

Figure 1: DO-ID Model



Source: Niegemann, H. (2008)

5.3 First Principles of Instruction by M. David Merrill

The First Principles of Instruction were derived by M. David Merrill through a review of Instructional Design theories and models, with the intention of identifying prescriptive principles based on commonalities between them (Merrill 2002, p. 43). In his review of instructional models, Merrill found that many existing theories suggest that the most effective learning products or environments

[27] For points 1 to 9 see Niegemann et al. 2008, p. 83-88.

are those that are problem-centred and involve the student in four distinct phases of learning. These phases of learning are:

- *Activation*: In this phase existing knowledge is activated to create new knowledge. The guiding question is: *'What is the existing knowledge of the learner and does instruction activate prior knowledge?'*;
- *Demonstration*: In this phase the learning content is demonstrated. The guiding question is: *'Does instruction demonstrate what is to be learned (i.e. through examples/non-examples, demonstration of procedures, visualisation of processes, modelling for behaviour)?'*;
- *Application*: In this phase the learners are required to apply what they have learned. The guiding question is: *'Are learners required to use their knowledge and skills to solve problems?'*;
- *Integration*: In this phase, learners integrate the learned content. The guiding question is: *'Are the knowledge and skills integrated (transferred) to the daily life of the learner?'* (Merrill 2002, p. 45-51).

Merrill states that instructional practice often focuses only on the demonstration phase and ignores the other phases in the cycle of learning (ibid., p. 44). The theories and models reviewed by Merrill were all problem-centred and included some or all of the four phases of learning. The aim of his review was to find common principles that can be found in most Instructional Design theories and models (although terms might differ) and which are, therefore, necessary for effective and efficient instruction (ibid.). Merrill derived five principles for the four phases of effective instruction from his review (ibid.). The first principle of instruction is framed by problem-centred instruction while the remaining four principles relate directly to each of the four phases of learning. Consequently, learning is promoted when

1. …learners are engaged in solving real-world problems.
2. …existing knowledge is activated as a foundation for new knowledge.
3. …new knowledge is demonstrated to the learner.
4. …new knowledge is applied by the learner.
5. …new knowledge is integrated into the learner's world (ibid.).

Merril's approach is discussed here as his review of prevalent instructional design models and theories can be seen as attempt to generate a meta-theory of instruction deriving the most relevant factors from a variety of instructional theories and models. Hence, it may contribute to a better understanding of the factors designers should consider when developing adequate and appropriate CBT/SBT.

5.4 Cognitive Apprenticeship Model by Brown, Collins & Duguid

The Cognitive Apprenticeship model is an instructional tool that is designed to enable learners to acquire thinking skills such as cognitive and meta-cognitive skills that can be applied to solve future problems (Liu 2005, p. 137). In cognitive apprenticeship learners observe how experts deal with problems and they learn to solve the same or similar problems by "learning-through-guided-experience" in authentic situations (ibid.). The Cognitive Apprenticeship Model, developed by Brown, Collins, and Duguid (1989), comprises six major phases:

1. *Modelling*: In this phase the expert demonstrates and explains a problem solving process / procedure in order that students can observe and understand.
2. *Coaching*: In this phase the learners themselves practice solving the problem / performing a task / procedure while the expert provides advice and corrects mistakes.
3. *Scaffolding*: Through increasing the complexity of problems and decreasing the level of assistance according to the students' progress, the experts progressively help the learners to successively achieve the objective / accomplish a task independently.
4. *Articulation*: During this phase the learners are given opportunities to articulate and clarify their own way of thinking.
5. *Reflection*: The learners compare their own thoughts with those of their peers and the experts.
6. *Exploration*: The learners manipulate and explore the learned skills or knowledge to promote their understanding (Liu 2005, p. 137).

The cognitive apprenticeship model is especially relevant for simulator-based training as it enables learners to develop greater problem-solving capacities.

5.5 Four-Component Instructional Design model (4C-ID)

The 4C-ID model, developed by van Merriënbör in 1997, focuses on the acquisition of competences or complex skills in technical training (van Merriënbör 1997). The basic assumption behind the model is that *'blueprints for complex learning can always be described by four components: learning tasks, supportive information, procedural information, and part-task practice'* (Kirschner/Merriënbör 2008, p. 246). Van Merriënbör uses the term *learning task* generically to refer to a variety of activities including case studies, projects, problems, etc.[28] Each learning task should offer *'whole-task practice confronting the learner with all or almost all of the constituent skills important for performing the task, including their associated knowledge and attitudes'* (Kirschner/Merriënbör 2008, p. 246). These learning tasks are progressively structured from easy to difficult and learner support diminishes throughout each task class (ibid.). *Supportive information* should help students learn to perform non-

[28] http://www.scitopics.com/Four_Component_Instructional_Design_4C_ID.html [accessed 30.10.2013].

routine aspects of a learning task, involving problem solving and reasoning. The *supportive information* supplies learners with information on how to best approach a presented problem. '*It provides a bridge between what learners already know and what they need to know to work on the learning tasks*'.[29] *Procedural information* allows learners to learn to perform routine aspects of learning tasks (tasks that are always performed in the same way). The information is presented to the learner at the time when that information is required. Procedural information becomes less prevalent the more expertise students gain (ibid.). Finally, *part-task practice* refers to additional practice of routine aspects in order to develop a high level of automaticity through repetition of a task (ibid.).

In 2007 Kirschner and van Merriënbör modified the 4C-ID model by developing 10 prescriptive steps to provide a practical version of the model for less experienced instructional designers (ibid., p. 244). They defined corresponding design steps for each of the four components. The following table provides an overview on the approach.

[29] http://www.scitopics.com/Four_Component_Instructional_Design_4C_ID.html [accessed 30.10.2013].

Table 1: The 4C-ID Model and 10 steps of complex learning

4C-ID	Ten steps to complex learning
Learning Task (authentic whole-task experiences based on real-life tasks)	1. Design Learning Tasks 2. Sequence Task Classes 3. Set Performance Objectives
Supportive Information (performance of non-routine aspects of learning tasks involving problem-solving and reasoning)	4. Design Supportive Information 5. Analyse Cognitive Strategies 6. Analyse Mental Models
Procedural Information (performance of routine aspects of learning tasks which are always performed in the same way)	7. Design Procedural Information 8. Analyse Cognitive Rules 9. Analyse Prerequisite Knowledge
Part-Task Practice (additional practice of routine aspects to develop automaticity)	10. Design Part-Task Practice

Source: Kirschner/Merriënbör 2008, p. 246.

Excursus: Tutoring Model for simulator-based training

Van Emmerik et al. (1997) developed a tutoring model for simulator-based training. In their model tutoring includes briefing and debriefing activities, referring to instruction both before and after a training session. Briefing activities are designed to inform trainees about the training task to be performed, while debriefing activities include evaluations of trainee performance after they have undertaken the task (van Emmerik et al. 1997, p. 12). Van Emmerik et al. described the tutoring process as automated or controlled by a human instructor - an intervention into the training process by the instruction system (human and/or computer). According to van Emmerik et al. there are different types of intervention (i.e. *'guidance, feedback, reinforcement, and diagnosis'*) (ibid.). Their intention was to develop a tutoring model for high-performance tasks. This led to the development of the following tutoring approach:

1. Survey of instructional guidelines: Conducting a review of the literature along the following questions is recommended in the initial stage of planning: *'Which tutoring techniques have been identified/studied?'*; *'Which tutoring techniques have been proven to be effective?'*; *'To what extent have tutoring techniques been found to be specific to a particular task or medium?'*.
2. Instructor task analysis: Focus is placed on tutoring aspects, instructor qualifications, and instructor courses in this stage. The most relevant questions are: *'Which tutoring techniques*

do instructors use and why?'; *'To what extent do instructors differ in their use of tutoring to particular trainees?'*; *'How do instructors adapt their way of tutoring techniques to particular trainees?'*; *'To what extent are tutoring techniques specific for a particular task?'*; *'To what extent does tutoring in the real system differ from instruction on a simulator?'*. It is recommended that structured interviews with tutors, (video) observation of training sessions, analysis of simulator recordings, etc. are used to obtain answers to these questions.

3. Elaboration and specification: On the basis of stages 1 and 2 the tutoring model can be elaborated and specified.
4. Testing of the model: This is achieved, for example, by assessing whether different designers arrive at a similar tutoring model or whether the model is able to describe the tutoring behaviour of an instructor.
5. Validation of the model by means of empirical studies: The essential question in this stage is: *'Which research techniques have been used to assess the effectiveness of tutoring?'*.

This approach to the development of a tutoring model in SBT is described here as it provides guidelines for developing effective tutoring models for SBT.

5.6 Other Models

The **ARCS model of Motivational Design** by John Keller (1983) defined four steps (**A**ttention, **R**elevance, **C**onfidence, **S**atisfaction) to promote and sustain motivation in the learning process.[30]

1. Attention: can be gained in two ways (1) by perceptual arousal (use of surprise or uncertainty to gain interest) and (2) by inquiry arousal (stimulates curiosity by presenting challenging questions or problems to be solved). Methods used to gain attention include, amongst others, active participation, variability, humour, specific examples, etc.
2. Relevance: the learning experience should be relevant to the learner in order to increase learner motivation. To achieve this language and concrete examples familiar to the learner should be used. Keller defined six major strategies: experience (learners should be aware of how the new learning will build on their existing knowledge/skills); present worth (explain to the learner what value the subject matter will provide for them today); future usefulness (explain to the learner what value the subject matter will provide for them in the future); needs matching (take advantage of the dynamics of achievement, risk taking, power, and affiliation); modeling (guest speakers, videos, etc.); and choice (allow the learners to use different methods).

[30] Information taken from http://www.learning-theories.com/kellers-arcs-model-of-motivational-design.html [accessed 10.02.2014].

3. Confidence: focuses on establishing positive expectations for achieving success among the learners. Strategies to establish confidence include: the provision of objectives and prerequesites (learners should be aware of performance requirments and evaluation criteria); growth of the learners (allow for small growth during the learning process); provide feedback; and learner control (learners should have the feeling that they have some degree of control over their learning and assessment).
4. Satisfaction: learners must obtain some type of satisfaction or reward from a learning experience (e.g. sense of achievement, feedback and reinforcement, etc.) (ibid.).

The **Goal-based Scenarios Model (GBS),** developed by Roger Schank (1996), is an approach founded in constructivist and cognitive theory which assumes that learners learn most effectively through 'learning by doing' - *'using simulations to generate meaningful learning'* (Zumbach/Reimann 2003, p. 183). Goal-based scenarios are used to impart procedural knowledge as well as factual (declarative) knowledge and should be taught in the context of application situations (Zumbach/Reimann 2003, p. 183). In GBS learners *'are responsible to pursue a goal by practicing skills or gathering and applying relevant information to solve the problem'* (Hsu/Moore 2011, p. 13). Essentially, the goal should be defined in a way that is meaningful, relevant, and interesting to the learners in order to stimulate their intrinsic motivation. The knowledge should be acquired in a way that enables students to use the acquired skills outside of the learning environment in day-to-day situations (Zumbach/Reimann 2003, p. 183). Learners themselves work through the content on pre-defined paths specified by the simulation, but are allowed to gather information outside the simulation in order to achieve their goals (Hsu/Moore 2011, p. 14). *'During the simulation, instruction, worked examples, well-told stories by experts, or other resources are given to learners to assist them in completing the task'* (ibid.). The GBS model includes the following steps:

1. *Learning Goals*: Skills that should be acquired by the learner. Two forms of knowledge are distinguished: process knowledge and content knowledge.
2. *Mission:* The task must be realistic, motivational, and interesting for the student.
3. *Cover Story*: The rationale that creates the need for the mission to be completed and offers learners opportunities to search for information or practice skills.
4. *Role:* Is the character the learner plays in the cover story. The role should be appropriate for the practicing of the necessary skills or for the use of the relevant knowledge in the scenario.
5. *Scenario Operations*: All operations that students undertake in the Game-Based Scenario in order to complete the mission.
6. *Resources*: All information learners need in order to acquire the targeted skills or content knowledge to complete the mission successfully.

7. *Feedback*: A consequence of action and primarily delivered through expert stories.[31]

[31] Points 1 to 7 see Hsu/Moore 2011, p.14.

6 Conclusions & recommendations for the development of CBT/SBT for drivers

This report aimed to provide an overview of the relevant educational theories and instructional design principles that should be taken into consideration in the development of CBT and SBT. The research undertaken indicates that a number of different theoretical and instructional design models are available to developers for planning and designing a learning intervention either on a computer or a simulator. The suitability of a theory and/or instructional design model is dependent on the learning objectives and learning outcomes to be achieved. As outlined in the introduction to this report, the national data obtained showed that currently no instructional design principles or educational theories are taken into consideration in the development of SBT in the partner countries, and that only in some of those countries are limited basic principles drawn upon during the development of CBT. This shortcoming is also identified in the literature. For example, de Groot et al. (2007) state that in order to achieve more effective learning with SBT, more emphasis must be placed on the didactical properties (rather than the fidelity) of the training programs (de Groot et al. 2007, p. 2). With regard to computer-based training it is important to note that design choices (e.g layout, density of material, sequencing of the modules, etc.) affect learner interpretation, possibly requiring them to undertake complex mental processing (see also cognitive load theory), and hence the design of a program impacts on the success of the learner (Mueller, 1998). Therefore, consideration of learning theories (depending on the intended learning objective and outcomes) and design principles, to ensure that the human-computer/ human-simulator interaction delivers the expected outcomes and does not ‘overload’ the learner, is essential. Consequently, this report underscores the necessity of applying learning theories and theoretical frameworks of some kind if desired learning outcomes and learning objectives are to be achieved via CBT and/or SBT. Different theoretical assumptions on learning lead to different instructional design principles (i.e. a behaviouristic learning environment may be the most appropriate for the learning of facts, whereas the adoption of a constructivist perspective may be more useful for developing problem-solving capacities). Therefore, computer- or simulator-based training for professional drivers should build on the rich sources of educational theory and instructional design as this will enhance content retention and facilitate the transfer of learning into practice.

The four pilot trainings developed and tested in work package 3 of the ICT-DRV project (three simulator-based training programs and one computer-based training scheme) began with an evaluation of theoretical considerations and instructional design principles. Several recommendations can be derived both from the literature review conducted for this report and the pilots developed and tested in the project. The following recommendation represents important principles which should be taken into consideration when developing CBT and SBT for professional drivers:

Learning is a social process - therefore CBT/SBT should allow student/tutor exchange

The research undertaken and the testing of the CBT/SBT pilots revealed that interaction between learners and/or a tutor has a positive influence on the learner and their learning process. Currently, however, unplanned interaction during breaks is often the only form of exchange between learners in CBT/SBT, and impact of the social process on learning is rarely considered in the development and implementation of CBT and SBT programs. Therefore, anticipating some kind of exchange between learners (in the form of a peer learning activity) during training could have a positive impact. In SBT peer-learning could be organised in which learners observe one another during driving simulation and exchange feedback afterwards. In CBT social exchange is slightly more difficult to implement, but exchange and discussion could be organised through a discussion platform, phases of personal attendance, or team assignments. The opportunity to exchange experience with other individuals (be it a tutor or other learners) during the learning process (online, via phone, or face-to-face) proved to be a real added value in the four pilots tested in the ICT-DRV project.

Provide some kind of tutoring in CBT/SBT for professional driver

On the basis on the interviews conducted and the literature review undertaken, the provision of some form of tutoring is recommended when implementing CBT/SBT. This is especially relevant for professional drivers as they are a very heterogeneous group, with diverse backgrounds and educational needs. The success of training through CBT/SBT depends on the students having access to guidance in the event that they require assistance. In CBT tutoring can be organised electronically, from distance, via a computer (e-mails, chats, video conferences, telephone calls, webinars etc.), or in the form of classroom tutoring sessions. In CBT therefore, online course elements, course elements with direct interaction between the learner and a tutor, and work-based learning elements should be combined to provide a suitable training environment. Consequently, a blended learning approach – where computer-based training sessions are intertwined with classroom or online training sessions – seems to be most promising for CBT. Tutoring sessions can also be beneficial in terms of motivating students using CBT in general and particularly before exams (i.e. prior to driver

CPC exams). In SBT training sessions should always be conducted by a tutor who explains the learning objectives and learning outcomes at the beginning of the session. Furthermore, the tutor should provide feedback to the trainees both during and after the simulator training. Without some form of tutoring (briefing, debriefing) trainees are more likely to perceive training on a simulator as a game rather than a real learning experience. Hence, briefing at the beginning of the training session, debriefing after the session, and peer learning are important aspects to be considered in the development and implementation of SBT.

CBT and SBT should have clear learning objectives and learning outcomes

Without an awareness of what the desired outcomes of instruction are, CBT/SBT programs are likely to be *'unfocused, confusing to the end-users, and quite possibly, useless'* (Chappell). Learning sequences in computer-/simulator-based training should ideally be outcome-oriented in terms of the EQF descriptors knowledge, skills and competences. Focus should be placed on the learner rather than on how the trainer will convey his/her knowledge to the learner. Furthermore, the application of the learning outcomes approach shifts the focus away from the amount of time spent in training (as currently part of the legal requirements for periodic/ continuous training of professional drivers) towards the attainment of a common minimum standard of knowledge, skills and competences, which is especially relevant for the recognition of non-classroom-based courses or prior knowledge. Furthermore, the learning outcomes approach allows customisation of a course to the skills shown by the learners.

Consider prior abilities and the work reality of professional drivers in CBT/SBT

The research process showed CBT/SBT to be most successful when modularised and described in terms of learning outcomes. This guarantees that the learner can, depending on his/her prior abilities and learning needs, individually choose those training modules that best fit his/her individual requirements. However, the heterogeneous nature of professional drivers' prior abilities is a key challenge within continuous/periodic driver training. Therefore, CBT and SBT courses should allow course elements to be added, skipped and/or adjusted, in dialogue with the tutor and on the basis of the prior abilities/experiences of the individual. This approach is strongly supported by the application of the EQF's learning outcomes approach because it moves the focus away from the amount of time spent in training and towards the attainment of a common minimum professional standard, while allowing for adjustment of the course content. Gagnè's Nine Events of Instruction proved to effectively support the integration of learner's prior abilities within the pilot training schemes developed in the ICT-DRV project. This approach strongly supports instructor-led distance learning as it enables a back and forth between instruction, self-study, practical application, guidance, and feedback. Furthermore, due to the fact that the work reality of professional drivers differs considerably, a number of constant background/basic elements of the course should be defined in the design of SBT (in order to ensure the common minimum course content as required by the legal framework of professional drivers' periodic training), while individual practice-tasks should be designed in order to be adaptable to (a) the learners' prior abilities and (b) the different work realities of the learner. Exercises should be prepared in such a way that they account for the prior knowledge of the student and their working context. Moreover, they should be neither too easy nor too difficult.

Combine theoretical and practical exercises in CBT/SBT for professional drivers to facilitate practice transfer

Practice transfer is a key challenge for the application of the learning outcomes approach because the EQF's learning outcomes approach requires the development of, and proof of the acquisition of, knowledge, skills and competences. Therefore, theoretical and practical components should alternate as the development of skills and competences often requires practical training elements. Practical exercises will thus facilitate the transfer of learning into practice. The ICT/DRV pilot training schemes revealed this combination of theory and practice to be a crucial element for the success of CBT/SBT course design. In SBT, examples that demonstrate how the simulator tasks correspond to real life situations should form part of the training and learning material. In CBT, on the other hand, it is often difficult to realise practice-tasks. In order to address this aspect the E-learning pilot course developed in the ICT-DRV project included a strong work-based learning component through the introduction of practice-tasks implemented into the learners' daily practice, enabling them to apply their knowledge and foster the development of skills and competences. This process was facilitated by the tutor. The 4C/ID-model (Four Components Instructional Design Model), which was specifically developed for conveying complex cognitive skills, was selected for one SBT pilot course and was ideally suited to the training potential of the simulator, as it allowed the learner to progress from less to more advanced practice tasks. The possibility to learn from mistakes also plays a key role in the transfer of learned content to the daily work practice of professional drivers.

Train-the-trainer in the use of CBT/SBT as a learning medium

The success of SBT and blended learning strongly depends on the quality and abilities of trainers who must have a thorough understanding all aspects of the use of a simulator or an E-learning programme to ensure that the training approach allows learners to achieve the defined learning outcomes and guarantees the transfer of learning to practice. Moreover, trainers need to be able to apply the learning technology so it supports their instruction as effectively as possible to ensure that technology-based training provides an added value for the learners. Furthermore, instructors also have an important role to play in motivating and guiding learners. However, the moderation of group coaching sessions, including the integration of just-received information and its relation to supportive information, requires not only very advanced subject-expertise, but also expertise in coaching, moderation and facilitation. Therefore, trainers / tutors should not only receive training in technical subjects (how to use a simulator or E-learning programme), but also instruction in pedagogical subjects (how to effectively teach with a simulator or E-learning program).

Documentation of learning outcomes of professional drivers in CBT/SBT

It is important that the learning outcomes acquired by trainees through CBT/SBT are evaluated and documented. A formative approach where the competences of the trainees are evaluated at the beginning of the training, at the mid-point of the training, and at the end of the training seems to be very effective in terms of facilitating successful learning. An evaluation of learning outcomes undertaken before implementation of the training allows the learner to articulate his/her training needs and to individually plan his/her learning pathway. A mid-point assessment allows the learner to obtain an overview on his/her understanding of the training content and articulate open questions. Finally, an evaluation of the learning outcomes at the end of a course allows the learner to understand what knowledge, skills and competences were acquired during the course and where there is still room for improvement. The documentation of learning outcomes in computer- and simulator-based training for professional drivers does not refer to testing or examinations taken at the end of the training course, but to the process of making the learning progress visible to the to the students, as this informs and motivates them. Furthermore, continuous professional development is only possible if a learner knows what he/she is able to do and where there is a need to develop his/her competences further.

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