COMPUTER-BASED INSTRUCTION IN TRAFFIC THEORY[1]

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Current methods of instruction in traffic theory fail to prepare students sufficiently for actual driving in every-day traffic. The relation between theory and practice, with respect to content and presentation, is often too vague. To achieve transfer to practice, instruction in traffic theory should be based upon task and context analyses. Furthermore, the knowledge to be learned should be presented in in a functionally valid and interactive learning environment. Multi media technology may provide the tools to create such an environment in a Computer Based Instruction (CBI) program. This paper presents the psychological and instructional analyses for developing such a new program.

1 INTRODUCTION

"Learning to drive can only be achieved in practice". This statement is true for contemporary driver education in the Netherlands because prevailing methods of instruction in traffic theory focus on preparing the student for the theoretical exam, not to prepare for actual driving in every day traffic. The driving schools of the Royal Netherlands Army acknowledge this problem of insufficient transfer. They decided to develop a new (computer based) course in traffic theory that is truly preparatory to the practical part of learning to drive. Computer Based Instruction (CBI), utilizing multi media technology, may make it possible to realize that goal, provided that the instructional design and the application of the technology is grounded in a consistent theory of learning and a sound framework of instruction. The present paper reports the results of the psychological and instructional analyses underlying the CBI program. First, the limitations of current driver education are discussed, followed by the adopted framework of learning. The fourth section reports on the analyses for determining the instructional material, and the main issues concerning instructional design are discussed

in the fifth section.

2 LIMITATIONS OF CURRENT DRIVER EDUCATION

A major drawback of current instruction in traffic theory is its limited transfer to practical driving performance. Two possible causes for this situation will be presented below. One concerns the philosophy of instruction and the selection of material. The other cause pertains to the instructional settings.

2.1 Philosophy of instruction

The contents of current instruction has been derived directly from statutory traffic rules. Instruction consequently focuses on learning definitions, rules, and the meaning of signs. It is up to the student to acknowledge the implications of the information for driving in actual task situations. For example, students learn to identify the sign indicating a motor-way, learn that a car belongs to the category of motor-vehicles, and learn that the speed-limit for motor-vehicles on motor-ways is 55 miles/hour. Because this information is of a formal nature and presented in a context that has no correspondence with the setting in which it has to be used, it is doubtful whether

this knowledge will be triggered and applied at the right moment.

The impact of theoretical instruction on actual task behaviour can improve significantly if the material to be learned is presented in the context of traffic situations that are functionally similar to the ones students are likely to encounter in real life. Students should therefore be taught how to identify a certain road as belonging to the category of motorways (both on its formal characteristics such as the sign, and on informal characteristics, like the presence of a dual carriageway and a hard shoulder) and how to link this knowledge directly to desired driving behaviour. Such an approach, rather than teaching general rules and principles, will more likely bring about transfer from theory to practice.

2.2 Instructional settings

An other criticism concerns the fact that the situations selected for instruction and testing often provide contexts that do not fit in with problems encountered in reality (e.g. "Should the white car (driving on an unpaved road) give right of way to the horse and cart (riding on a paved road)?"). A related objection that specifically applies to the testing procedure concerns the phrasing of questions. Questions often explicitly refer to the nature of the problem (e.g. "should the car give right of way to the bike?"). In other words, the student is 'cued' by the way the question in phrased. This is very unlike real-life situations, in which drivers have to recognize the kind of traffic situation, identify the problem, and retrieve the required associated knowledge to solve it. It would be better if questions are formulated in a more open and non-directive form, like "should you stop or continue?" or even better: "what should you do next?".

3 PSYCHOLOGICAL FRAMEWORK

Cognitive psychology has long been dominated by the view that behaviour is the result of strategies executed on internal knowledge representations (e.g. [1]). Accordingly, studies on how knowledge is represented mentally and how such representations are acquired were believed to provide the key to understanding learning and behaviour. A major criticism against this view is that it discards the influence of the environment (the external representations) in which the knowledge is acquired or applied (e.g. [2]). This criticism has emanated in a new movement in cognitive psychology: situated action theory (e.g. [3,4]). Situated action theorists emphasize that task performance is to a large extent regulated by cues of the specific context. Consequently, studies on the acquisition, representation, and application of prerequisite task knowledge should address the important role of the environment.

The views above have different implications for instructional design. The traditional view emphasizes the importance of acquiring generic abstract mental representations of task knowledge, whereas situated action theories stress the significance of functional and physical validity of the learning environment.

For the present CBI program we adopt the notion of situated action theories that all knowledge is inextricably a product of the activity and situations in which it is acquired. The implication for instruction is that the process of knowledge acquisition should be guided by presenting information in a variety of realistic settings, so that students learn to associate and use the relevant knowledge with the implicit and explicit correlates and restrictions of the context in which the knowledge eventually needs to be applied. This approach requires students to be able to recognize and categorize different (traffic) situations. How this will be achieved is explained in the next sections.

4 INSTRUCTIONAL ANALYSES

The framework presented above makes clear that a driving task can not be defined or analyzed in isolation, but needs to be considered in realistic traffic situations. For the present CBI program, the existing complexity and variability of traffic situations is captured in a limited set of prototypical road categories. The categorization is derived by considering a certain road's function and its setting. Three functionalities are distinguished: roads serving local traffic, interlocal roads designed to serve large quantities of traffic with long-distance destinations, and roads designed to connect local with interlocal roads. Two settings are distinguished: within and outside the city limits (see Figure 1).

4.1 Task analysis

For each road category, the associated tasks have been identified. For example, when driving on a motor way, a driver needs to be able 'to turn onto an approach road and join the traffic', 'to drive and follow', 'to overtake', and 'to exit'. Each of these identified tasks have been analyzed, resulting in a specification of the prerequisite knowledge and skills, criteria for adequate task performance and a list of possible task conditions and complications. Correctly driving onto a motorway, for instance, requires the driver to recognize the approach road (on its formal and informal characteristics), to be familiar with the appropriate driving procedures, and to be aware of potential complications and to know the proper actions when they do occur.

4.2 Training analysis

Results of the task analyses provided the input for the specification of the learning objectives, comprising a behavioral component (e.g. "maintaining an appropriate following distance"), a conditional component (e.g. "on a clinker paved right-of-way urban road under rainy conditions"), and a criterion component (e.g. "20-40m"). Learning objectives can refer to factual knowledge (e.g. the meaning of a particular road sign), conceptual knowledge (e.g. categorizing a road scene as member of a certain category), procedural knowledge (e.g. prescribed action sequence when overtaking), or understanding principles (e.g. the relation between road conditions and stopping distance). The appropriate instructional strategy and media varies to each type. It is beyond the scope of this paper to discuss the guidelines for instruction in detail, but a few important issues are discussed in the following section.

5 INSTRUCTIONAL DESIGN ISSUES

Various methodologies for instructional design have been proposed in the literature (e.g. [5,6]). For the present CBI program we adopt an eclectical approach. Some important design issues are discussed in the following paragraphs.

5.1 Learner control

A major question in the design of a (computer based) instruction program is how much guidance should be provided. We adopted an approach with both directive and explorative characteristics. A directive approach is used for teaching arbitrary information. For instance, the design of traffic signs is often arbitrary, as is the rule to keep the right (or left) side of the road. It is rather senseless to let students 'discover' this knowledge. Explorative teaching is used for material in which clear relations can be distinguished. For example, the design of road types is logically related to their function, and it is instructive to let student actively discover these relations.

5.2 Mastery learning

For the present CBI program it was decided to embrace the concept of mastery learning [7], stating that the selection and presentation of instructional material should accommodate each individual student. In order to achieve the goal that all students should eventually pass on all learning objectives, the program frequently tests the student's performance. The results are used to on-line adjust the type and amount of instruction to the individual's need.

5.3 Integration of theory and practice

The present CBI program aims to forward the integration of theory and practice by distinguishing a main and a secondary phase. In the first phase, students receive computer-based instruction in relatively standard traffic situations and associated task performance. This prerequisite theoretical knowledge is subsequently put into practice and consolidated during practical driving lessons (or simulator training). The second phase starts with computer-based instruction addressing problematic and less regular situations that (sometimes) require specially adjusted task behaviour. Finally, if possible, this knowledge is again consolidated in practice lessons.

5.4 Selection and use of media

Students can make the link between theoretical knowledge and practice more easily if the information is presented in real-life like contexts. Perhaps the most salient characteristic of real-life traffic is that it is dynamic. Digital video technology makes it now possible to present dynamic situations in an instructional setting. Video is suited to demonstrate the characteristics and function of a certain road design, to show (potential) problems and conflicts in traffic situations, to show the outcomes of different reactions to a certain problematic situation, and to show the antecedents that produced the problematic situation in the first place. The more static aspects of traffic can be addressed with photo's.

Special attention is required with respect to the use of visuals. Current methods of instruction widely use helicopter-view diagrams of three- or four-way crossings with conflicts between all kinds of road users. This type of presentation is very popular, possibly because it allows rules of way to be explained in a compact and orderly fashion. Instructors generally experience this also as an effective procedure because students learn to solve such problems rather quickly. There is evidence, however, that this type of knowledge fails to transfer to actual task behavior [8], because the driver's view through the windshield is from a totally different perspective. Too many (visual) transformations are required to acknowledge the correspondence between instructional and actual context. In the present program, visuals are therefore presented from the driver's viewpoint, whenever possible.

6 CONCLUSION

The present paper reports on the development of a CBI program for instruction in traffic theory. The adopted framework demands the information to be presented in functional and realistic task settings. Multi media technology offer the means to accomplish these instructional principles.

The development of the program is currently underway. Instructional analyses have been completed and guidelines for instructional design are specified. The driving schools are working out detailed scenario's for instruction, including specifications on the required instructional material (photo's, video, text for spoken comment). A start has been made to collect these materials. In order to test the proposed method of instructional design, a prototype of the program will be developed and, subsequently, evaluated.

Developing a multi media CBI program for traffic theory along the lines presented in this paper is a time and labour consuming job, taking considerable more energy than simply transforming the old curriculum into a computerized version. The reward for these efforts is a program addressing and presenting knowledge in a fashion that is relevant to actual driving. It is expected that through this program, students need fewer practical driving lessons to become better drivers.

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BIOGRAPHY

KAREL VAN DEN BOSCH carried out research on visual word recognition for which he received a Ph.D from the University of Nijmegen in 1991. At TNO he worked on projects involving the development of Computer Based Instruction programmes (e.g. instruction in traffic theory). More recently, he has carried out several projects on training simulators. His special interest concerns the development of low-cost training aids integrating simulations of target systems with instructional facilities (add-on tutorials, feedback, guidance, etc), thus providing for effective and efficient learning environments.