Toward Automated Driver Training: A Usability Evaluation of a Driving Skills Training System

Jin-Long Lin [1], Chen-Rao Zhong [1], Peng Liu [2], Meng-Cong Zheng [3,*]

[1] Doctoral Program in Design, College of Design, National Taipei University of Technology, Taiwan, China
[2] Huizhou Desay SV Automotive Company Ltd., Huizhou, Guangdong, China
[3] Department of Industrial Design, National Taipei University of Technology, Taiwan, China

*zmcdesign@mail.ntut.edu.tw

Abstract. With the rapid advancement of intelligent driving and human machine interaction technologies, an increasing number of in-vehicle applications are being integrated into real driving contexts. In this study, we investigate the interaction design of an innovative in-vehicle application, the Driving Skills Training (DST) system, and evaluate its usability in automated driver training scenarios. To identify potential usability challenges in real use, a formative usability evaluation of the DST system was conducted. Participants' subjective perceptions of system usability and user experience were measured using the system usability scale and the AttrakDiff Mini questionnaire, while usability issues and operational difficulties were documented through the think-aloud protocol. The results provide empirical evidence for optimizing interface design and refining system functionality of DST systems, and offer design implications for future in-vehicle training systems that support automated driver training.

Keywords: Driving skills training, In-vehicle human-machine interface, Human-computer interaction, User experience, Usability evaluation

1 Introduction

With societal development and rising living standards, driving skills are gradually shifting from an "optional consumer activity" to a fundamental life skill, and the demand for driver training (also known as "driver education") has shown a sustained upward trend [1]. Although the market size of China's driver training industry has fluctuated in recent years due to factors such as demographic changes and slower economic growth, the overall market demand remains high in a country with such a large population. According to statistics from the Ministry of Public Security of the People's Republic of China, approximately 12.58 million new driver's licenses were issued in the first half of 2025 [2], and the total number of new drivers in 2024 reached 22.26 million [3]. Meanwhile, the market size of China's driver training industry in 2024 was approximately CNY 76.1 billion, and the industry is gradually moving toward professionalization and intelligence [1].

I. A. Khan et al. (eds.), *Proceedings of the 2026 5th International Conference on Educational Innovation and Multimedia Technology (EIMT 2026)*, Atlantis Highlights in Social Sciences, Education and Humanities 51,
https://doi.org/10.2991/978-94-6239-691-3_44

Currently, driver training in China primarily combines theoretical learning with practical driving exercises. Theoretical training typically involves offline classroom instruction, online video learning, and mobile-based practice question banks, covering traffic regulations, driving operation standards, and basic vehicle knowledge. In China's driver licensing examination system, theoretical tests include the Road Traffic Safety Laws and Regulations Examination (Subject 1) and the Safety and Civilized Driving Knowledge Examination (Subject 4). Practical training is delivered through driving simulators or on-road vehicle training, helping learners acquire basic driving skills and become familiar with vehicle handling. Corresponding practical exams include the Driving Skills Test (Subject 2) and Road Driving Test (Subject 3).

However, traditional driver training often relies on one instructor supervising multiple learners, with significant variations in teaching methods and practical guidance among instructors. When faced with large training demands, such experience-dependent approaches may lead to inconsistent training quality, affecting both learning outcomes and instructional efficiency. Enhancing the stability and effectiveness of driver education while ensuring safety has therefore become a critical issue in China's driver training industry. Consequently, developing and designing driving skills training (DST) systems with good usability and instructional support capabilities holds significant practical importance and application value.

2 Literature Review

2.1 Driving Skills Training (DST)

High-quality DST is widely recognized as a critical prerequisite for reducing traffic accident rates and improving road traffic efficiency. In recent years, driving simulators have been increasingly used in driver training programs. However, previous studies indicate that simulator-based training provides limited benefits for real-world driving performance and should not replace practical driving training [4]. Compared with simulator-based training, training conducted directly in real vehicle environments is more conducive to developing operational cognition and behavioral patterns consistent with actual driving situations. Nevertheless, most existing driver training systems are implemented as standalone simulators rather than being integrated into real in-vehicle systems. Consequently, developing an in-vehicle DST application system tailored to real driving contexts and equipped with instructional support capabilities holds important research and practical significance.

2.2 In-Vehicle Human Machine Interfaces

In-vehicle human–machine interfaces (HMIs) refer to the comprehensive set of interfaces and mechanisms through which drivers or passengers acquire information, control tasks, and interact with vehicle systems during use. Well-designed in-vehicle HMIs can reduce the cognitive effort required to extract information, enabling drivers to obtain necessary information within minimal glance time. Additionally, interface consistency, predictability, and clear visual structure can enhance overall system usability and user satisfaction. Existing studies have demonstrated that factors such as text clarity, icon size, layout of interface elements, and interface design type significantly influence the usability performance of in-vehicle HMIs [5]. Moreover, because simulator-based training differs substantially from real-world driving instruction, findings derived from simulator studies provide limited direct guidance for in-vehicle training applications. Therefore, the usability principles identified in in-vehicle HMI research were adopted as the theoretical basis for the design of the DST in-vehicle interface in this study.

2.3 Usability Evaluation Methods

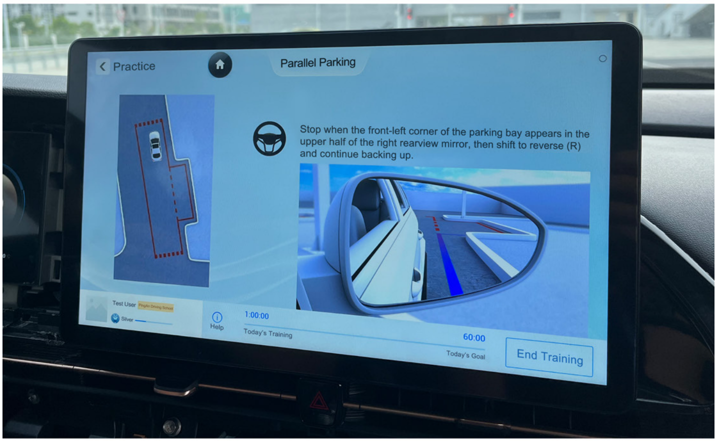
Usability engineering is a user-centered system evaluation approach aimed at systematically assessing a product or interface's effectiveness, efficiency, and satisfaction within specific usage contexts. Depending on the research objectives and stage of product development, usability evaluation is typically categorized as either formative or summative. Given that the DST system in this study is still undergoing functional refinement and interface optimization, a formative usability evaluation strategy was adopted. The Think-Aloud method was employed to gain in-depth insights into the practical issues and cognitive difficulties encountered by users during operation. In addition, standardized questionnaires were used to quantitatively collect participants' subjective assessments of system usability and user experience. The System Usability Scale (SUS) was applied to evaluate overall system usability [6], while the AttrakDiff questionnaire was used to assess user experience across multiple dimensions [7].

3 Methodology

3.1 Design of the In-Vehicle DST Application System

During the initial product development phase, this study focused on the Driving Skills Test for the closed-field practical examination (Subject 2) as the primary training content. Targeting the core needs of learners during the foundational practical stage, an in-vehicle DST application system was developed (see Figure 1). The system covers four typical training tasks in the Subject 2 examination: reverse parking, parallel parking, curved driving, and right-angle turns. In terms of functional design, each training task incorporates two core features: automated driving demonstration and voice-guided practice. In the automated driving demonstration mode, learners sit in the driver's seat and observe the vehicle autonomously completing the standardized examination procedure in a real-field environment, allowing them to intuitively understand driving trajectories, steering timing, and operational rhythm. The voice-guided practice mode integrates verbal prompts with visual feedback from the in-vehicle interface to guide learners in performing the required actions at critical points, providing instructional support akin to real-time coaching. Furthermore, the system records the vehicle's trajectory and performance during practice and visualizes them upon completion. For example, during reverse parking exercises, the visualization highlights points where learners crossed the lines or incurred penalties, allowing them to clearly review their performance.

(a)



(b)

Fig. 1. Design samples: (a) Home interface; (b) Parallel parking instructional interface.

3.2 Evaluation Procedure and Methods

The usability evaluation of the DST system was conducted in a closed automotive test facility. The facility was designed according to actual driving training and examination standards, including various parking types, traffic signals, right-angle turns, and S-shaped curves, to simulate realistic closed-field driving training scenarios. Novice drivers were recruited as participants for the usability test. During the test, participants were required to operate the DST system to complete designated training tasks while employing the concurrent Think-Aloud method, verbally expressing their operational decisions, understanding process, and encountered difficulties. This approach enabled the collection of potential usability issues in terms of interaction design. After completing the test, participants rated the system using the SUS and the AttrakDiff questionnaire to obtain overall subjective assessments of system usability and user experience.

3.3 Participant Information

According to Nielsen's principles for usability testing, inviting at least five users typically allows identification of approximately 85% of the major usability issues [8]. Based on this guideline, five participants (Average age = 23.2 years, SD = 2.59) were recruited for the formative usability evaluation. Among them, two participants had no prior driving experience and had not obtained a driver's license, while the remaining three participants had licenses but limited driving experience and had not driven regularly since obtaining their licenses.

4 Analysis and Discussion

4.1 Usability Issues

A total of 133 usability issues identified by participants during interaction with the DST system were collected through the Think-Aloud protocol. Referring to established classification frameworks for in-vehicle HMI usability issues, these problems were categorized into four dimensions: Functionality, Interactivity, Sensory Experience, and Emotional Response. Table 1 presents several representative examples of usability issues identified in the DST system.

Table 1. List of usability issues identified in the DST system (partial).

ID	Functional Module	Usability Issue	Violated Dimension	Violated Criterion
1	Reverse Parking	The interface text reminding users to "quickly turn the steering wheel fully to the right" is too lengthy, requiring extended reading time.	Sensory Experience	Comprehensibility
2	Reverse Parking	No voice prompt is provided to indicate task completion after reverse parking is finished.	Functionality	Completeness
3	Parallel Parking	No turn signal reminder is provided during parallel parking; the system does not prompt users to activate the left turn signal when exiting the space.	Functionality	Completeness
4	Curved Driving	Excessive voice instructions with overly short intervals (e.g., tire-edge warnings and steering commands are announced simultaneously).	Sensory Experience	Comfort
5	Right-Angle Turn	The system prompts "quickly straighten the steering wheel" before the turn has been completed.	Interactivity	Effective Feedback

Based on the analysis of these usability issues, several directions for system improvement are proposed. First, dynamic visual aids should be incorporated into the interface, with clearly defined target positions and trajectories for each operation, to support users' intuitive understanding of task procedures. Second, the voice-guided practice function should be adapted to different user proficiency levels: novice users may receive more detailed operational guidance, whereas experienced users could be provided with fewer prompts or only essential instructions. Highly proficient users could be allowed to engage in autonomous practice or simulated examinations. From an interface design perspective, text readability should be enhanced and supplemented with graphical explanations to improve information comprehension. It is also critical to precisely control the timing of voice prompts. Finally, appropriate error-correction and fault-tolerance mechanisms should be implemented.

4.2 Subjective Evaluation Results

For system usability assessment, the average SUS score was 52.5 (SD = 18.37), corresponding to a rating between OK and GOOD, which indicates marginal acceptability (see Figure 2 (a)). Higher SUS scores indicate greater ease of use (range: 0-100). From a usability perspective, participants' evaluations suggest that the DST system exhibits relatively low ease of use, with substantial room for improvement.

Results from the AttrakDiff (see Figure 2 (b)) show that the mean score for pragmatic quality (PQ) was 0.65 (SD = 1.79), and the mean score for hedonic quality (HQ) was 0.70 (SD = 1.63). The coordinate (0.65, 0.70) falls within the "neutral" region, indicating moderate performance in both utility and enjoyment. The mean score for overall attractiveness (ATT) was 0.80 (SD = 1.30), which also lies within the neutral range. Overall, the DST system demonstrated relatively unremarkable performance across user experience dimensions, suggesting the need for further enhancement of both pragmatic and hedonic qualities to increase users' willingness for continued use.

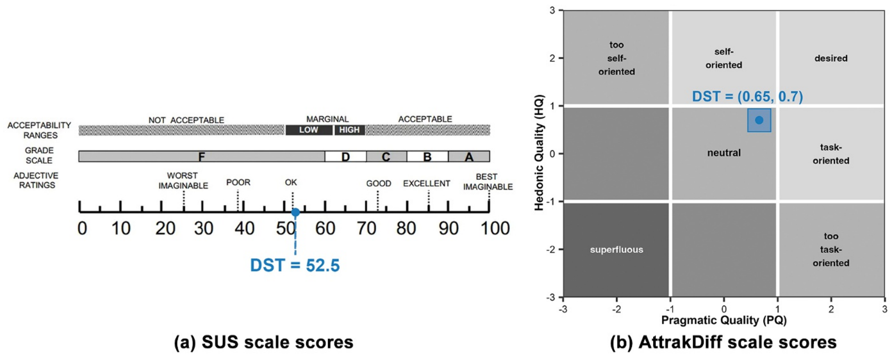


Fig. 2. SUS and AttrakDiff scale scores of the DST system.

5 Conclusion

This study conducted a formative usability evaluation of a self-developed DST system, an efficient and valuable approach during the early stages of system deployment. The evaluation revealed multiple issues related to functional completeness, interaction feedback, sensory experience, and users' emotional trust. Subjective assessment results further indicated that the system's overall usability and user experience remain at a moderate level. Based on these findings, future iterations will optimize the interface design and interaction logic of the DST system and include continuous follow-up evaluations, thereby providing practical guidance for the design of future in-vehicle DST systems.

References

1. Zhiyan-Consulting, Report on the Market Development Scale and Future Outlook of China's Driver Training Industry, 2026–2032. Available online: Guotai Junan Securities Research. https://www.chyxx.com/research/1240561.html (accessed on 6 March 2026).
2. China, T.M.o.P.S.o.t.P.s.R.o., China now has 460 million motor vehicles and 550 million licensed drivers nationwide. Available online: https://www.mps.gov.cn/n2254098/n4904352/c10143192/content.html (accessed on 6 March 2026).
3. China, T.M.o.P.S.o.t.P.s.R.o., China's total number of motor vehicles has reached 453 million, and the number of licensed drivers has reached 542 million nationwide. Available online: https://www.mps.gov.cn/n2254314/n6409334/c9939035/content.html (accessed on 6 March 2026).
4. Krasniuk, S., et al., The effectiveness of driving simulator training on driving skills and safety in young novice drivers: A systematic review of interventions. Journal of Safety Research, 2024. 91: p. 20-37.
5. Lin, J.-L., et al., Driver-Centric Design: Empirical Strategies for Optimizing the Visualization of Driving Information on Vehicle Liquid Crystal Display Dashboards. IEEE Access, 2025.
6. Brooke, J., System usability scale (SUS): a quick-and-dirty method of system evaluation user information. Reading, UK: Digital equipment co ltd, 1986. 43: p. 1-7.
7. Hassenzahl, M. and A. Monk, The inference of perceived usability from beauty. Human–Computer Interaction, 2010. 25(3): p. 235-260.
8. Nielsen, J. and T. Landaucer, A," Mathemetical Model of the Finding of Usability Problems," In proceedings of INTERCHI'93. 1993, Amsterdam, The Netherlands.