INTEGRATING VIRTUAL REALITY AND GAMIFICATION IN DRIVER TRAINING: THE LEARN2DRIVE PROTOTYPE

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ABSTRACT

Objective: Driving education in Malaysia plays a vital role in producing safe and competent drivers, yet many learners struggle with low confidence, limited engagement, and insufficient exposure to real-world driving conditions. Traditional training approaches such as classroom instruction, written tests, and limited on-road practice often fail to provide realistic or repetitive learning experiences necessary for skill mastery. To address these challenges, this study introduces Learn2Drive, a Virtual Reality (VR)-based prototype enhanced with gamification to improve learner confidence, motivation, and understanding in driver education.

Research Method: Developed using an Agile methodology, the system integrates immersive simulation, interactive feedback, scoring mechanisms, and achievement rewards within a realistic 3D driving test environment. The prototype was evaluated through a small-scale exploratory study involving twenty novice drivers preparing for their licensing tests. Data were collected via observations, user testing, and post-session interviews to assess five key aspects: learner confidence, motivation and engagement, understanding of test procedures, system usability, and perceived realism.

Findings: The results revealed notable improvements across all aspects, with participants reporting increased confidence, reduced anxiety, and greater engagement through gamified feedback and scoring features. Learners also demonstrated better comprehension of driving test procedures and expressed high satisfaction with the VR environment's realism and usability. Minor challenges were identified, including limited hardware accessibility and the absence of dynamic traffic conditions, which may be addressed in future iterations.

Originality: Overall, the findings confirm that integrating VR and gamification provides a safe, engaging, and learner-centered approach to driver training. The Learn2Drive prototype represents an innovative step toward modernizing Malaysian driver education, offering a scalable, technology-enhanced solution that bridges the gap between theoretical instruction and real-world driving practice. Future development will focus on incorporating AI-based virtual instructors, diverse driving scenarios, and improved hardware accessibility to support wider adoption in educational institutions.

Keywords: Virtual Reality (VR), Gamification, Driver Education, Simulation-Based Learning, Educational Technology

1. INTRODUCTION

Driving education in Malaysia plays a critical role in preparing individuals to operate vehicles safely and independently. Beyond its practical function, driver training contributes to social mobility by enabling access to education, employment, and broader community participation. Despite its importance, many learner drivers encounter significant challenges during training. Novice learners frequently report anxiety, reduced confidence, and fluctuating motivation, factors that may negatively influence skill acquisition and performance during licensing examinations. Such psychological barriers can impede readiness for independent driving and may ultimately affect long-term road safety outcomes.

Conventional driver training in Malaysia typically consists of classroom-based theoretical instruction, written assessments, and limited on-road practice sessions. While these approaches support foundational knowledge acquisition and basic vehicle control, they may not provide sufficient opportunities for repeated, realistic exposure to complex traffic scenarios. As a result, learners may struggle to develop advanced hazard perception and decision-making skills required for safe driving in dynamic environments. Insufficient experiential practice can therefore limit procedural mastery and reduce learners' preparedness for both licensing tests and real-world driving situations.

Advances in educational technology have introduced innovative approaches to address these limitations. Virtual Reality (VR), in particular, offers immersive and interactive environments that enable learners to engage in realistic driving simulations within a controlled and risk-free setting. VR-based training allows repeated practice of specific manoeuvres and exposure to simulated hazards without real-world consequences, thereby supporting experiential learning and skill reinforcement. Prior research in immersive training contexts indicates that VR environments can enhance practical skill development, learner confidence, and readiness for authentic task performance. In addition to improving procedural competence, immersive systems have been associated with increased engagement and motivational outcomes due to their interactive and sensory-rich characteristics.

Gamification represents another pedagogical strategy increasingly applied in technology-enhanced learning environments. By incorporating game elements such as points, levels, challenges, and rewards into instructional design, gamification seeks to foster active participation, persistence, and goal-oriented behavior. When integrated with immersive VR systems, gamified features may further enhance learner engagement, reinforce performance feedback, and promote sustained practice. Existing research suggests that the combination of VR immersion and motivational design strategies can lead to improved learning satisfaction, confidence, and performance outcomes compared to traditional instructional approaches.

In response to these developments, the present study introduces Learn2Drive, a VR-based driver training prototype developed to enhance Malaysian driving education through immersive simulation and gamified learning mechanisms. The system was developed using an Agile methodology to support iterative refinement and user-centered design. This study aims to (i) outline the theoretical foundations of VR and gamification in educational contexts, (ii) describe the design and development of the Learn2Drive prototype, and (iii) examine its potential to improve learner confidence, motivation, and readiness for licensing examinations.

2. LITERATURE REVIEW

2.1 VIRTUAL REALITY IN EDUCATION

Virtual Reality (VR) has emerged as one of the most promising innovations in modern pedagogy. By enabling learners to engage in highly interactive and sensory-rich environments, VR enhances experiential learning and deepens knowledge acquisition. Unlike traditional two-dimensional media, VR immerses learners in three-dimensional spaces, allowing them to interact with objects and environments in ways that mimic real-world experiences. Research shows that VR contributes to increased learner engagement, improved retention of knowledge, and stronger emotional connections to content (Noor & Ullah, 2024).

In skill-based training, VR has been particularly impactful. Fields such as medicine, aviation, and engineering have adopted VR simulations to provide learners with safe, repeatable, and controlled training experiences. For example, medical students can practice surgical procedures in VR without patient risk, while aviation trainees can rehearse flight protocols under varied weather conditions. Studies have found that VR-based training significantly improves learners' confidence, decision-making, and readiness for real-world applications (Pears et al., 2023). These precedents suggest that VR can be equally effective in driver education, where learners benefit from repeated exposure to test environments and controlled practice in hazardous scenarios.

2.2 GAMIFICATION IN LEARNING

Gamification refers to the application of game elements such as points, levels, challenges, and rewards in non-game contexts to increase engagement and motivation. Educational research demonstrates that gamification fosters persistence, encourages goal-directed behaviour, and transforms routine learning tasks into enjoyable and interactive experiences (Ramos et al., 2024). Gamification operates on the principles of both intrinsic and extrinsic motivation: while learners may be extrinsically motivated by rewards such as points or badges, they are also intrinsically motivated by the satisfaction of achievement, mastery, and progress (Hewko & Shaigetz, 2024).

In the context of driver training, gamification holds unique educational value. Driving requires not only theoretical understanding and technical skill but also sustained practice and resilience in overcoming mistakes. By embedding game mechanics into simulations, learners can receive immediate feedback, track their performance, and practice repeatedly without perceiving the training as repetitive or stressful. Studies show that gamified VR environments can reduce performance anxiety, enhance confidence, and increase motivation through immersive and goal-oriented practice (Yang & Oh, 2022; Chen, 2020). Therefore, integrating gamification into driver training simulations can transform the learning experience, promoting active participation and improving skill retention.

2.3 DRIVING SIMULATION TECHNOLOGIES

Driving simulators have a long history of use in both commercial and educational contexts. They range from high-fidelity simulators employed in professional driver training to software-based applications designed for novice drivers. While traditional simulators have proven effective for skill development and hazard perception training, many still lack the immersive qualities of Virtual Reality (VR) or fail to incorporate gamification strategies that enhance learner engagement and motivation (Bosch-Barceló et al., 2024). Moreover, commercial simulators are often expensive and inaccessible to smaller driving schools or individual learners preparing for licensing tests, limiting their widespread adoption (Pears et al., 2023).

Recent studies indicate that learners using VR-based driving simulators demonstrate significantly higher confidence, spatial awareness, and decision-making ability compared to those trained through conventional methods (Noor & Ullah, 2024; Yang & Oh, 2022). These improvements are attributed to VR's immersive environments, which allow learners to safely experience and respond to realistic road scenarios. However, challenges remain—particularly in ensuring that simulations accurately replicate real-world physics, provide cost-effective hardware solutions, and integrate sound pedagogical principles into design (Zhao & Li, 2022).

To address these limitations, the Learn2Drive prototype integrates immersive VR simulation with gamified learning mechanics tailored to national driving test requirements. By combining experiential simulation with motivational design strategies, the system seeks to provide a more engaging, accessible, and pedagogically grounded training experience for Malaysian learner drivers. The following section describes the design and development of the Learn2Drive prototype, including its system architecture, development tools, and the Agile methodology employed to support iterative refinement and user-centred improvement.

3. METHODOLOGY

The development of Learn2Drive followed the Agile software development methodology, which emphasizes flexibility, collaboration, and continuous improvement. This approach was chosen to ensure that the prototype evolved effectively through user feedback while maintaining alignment with the project's pedagogical and technical goals. The Agile process used in this project consisted of seven iterative stages Planning, Design, Development, Testing, Deployment, Review, and Launch as illustrated in Figure 1.

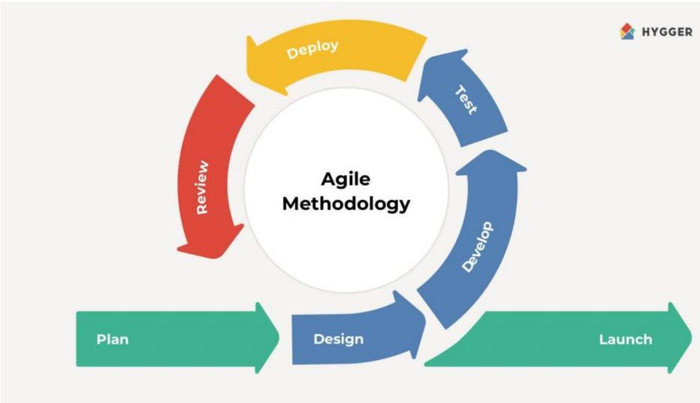

Figure 1: Agile development process for the Learn2Drive prototype

Source: (Hygger.io Guides, n.d.)

3.1 PLANNING

The planning stage established the foundation for the development of the Learn2Drive system by systematically identifying both pedagogical and technical requirements. Requirements analysis was informed by consultations with driving instructors, learners preparing for licensing examinations, and a review of relevant literature on virtual reality–based education and gamification design (Hewko & Shaigetz, 2024; Ramos et al., 2024). This stage resulted in a comprehensive set of functional specifications and an implementation roadmap to guide subsequent development phases. The primary objectives defined during planning were to simulate a realistic driving test track aligned with national testing standards, to develop an immersive VR environment that supports experiential and practice-based learning, and to integrate gamification elements designed to enhance learner engagement and motivation throughout the training process.

3.2 DESIGN

The design phase focused on developing the system architecture and user interface based on the identified requirements. The team created low-fidelity prototypes and visual mock-ups to define the driving environment, interface layout, and game mechanics. Key design elements included the creation of a 3D driving test circuit, interactive user dashboard, and visual feedback system. The Unity Game Engine and Blender were selected as the primary tools due to their strong capabilities in 3D modelling, interaction design, and VR integration.

3.3 DEVELOPMENT

During the development stage, the system's core functionalities were implemented. This involved scripting vehicle control mechanisms, traffic behaviour, and gamified interactions such as scoring and rewards. 3D models of roads, vehicles, and environmental assets were created and integrated into the Unity environment. Development tasks were organized into short sprints, ensuring that each sprint delivered a working feature that could be tested immediately. Continuous integration allowed early detection of errors and seamless progress across development cycles (Noor & Ullah, 2024).

3.4 TESTING

The testing phase was conducted at the end of each sprint to evaluate system stability, performance, and user experience. Both technical testing (to detect bugs and errors) and user testing (to assess usability and engagement) were performed. A small group of learner drivers and instructors participated in testing sessions. Their feedback helped identify issues in navigation, visual feedback, and point systems. Iterative testing cycles allowed for immediate refinements, improving functionality and educational effectiveness (Chen, 2020).

3.5 DEPLOYMENT

In this stage, the working prototype was deployed on compatible VR hardware such as Oculus Rift and HTC Vive. The deployment process involved configuring the VR environment, testing hardware compatibility, and ensuring smooth real-time performance. This step allowed for a more authentic simulation experience, bridging the gap between theoretical knowledge and practical driving application.

3.6 REVIEW

Following deployment, user feedback was systematically reviewed to evaluate the system's pedagogical and technical impact. The development team analysed learner performance data, motivation levels, and feedback from instructors. Based on this analysis, iterative refinements were made to improve environmental realism, adjust difficulty levels, and fine-tune gamification elements. This review stage ensured that the prototype continuously evolved in response to user needs (Bosch-Barceló et al., 2024).

3.7 LAUNCH

The final stage involved the official launch of the Learn2Drive prototype for pilot testing within a Malaysian driving school context. The launch phase focused on observing real-world usability, assessing learner confidence, and validating system performance under operational conditions. Preliminary results indicated that learners reported higher engagement, reduced anxiety, and improved understanding of driving procedures, confirming the effectiveness of integrating VR and gamification into driver training.

4. PROTOTYPE DEVELOPMENT

The Learn2Drive prototype integrates educational content, game mechanics, and immersive technology into a unified learning system designed to enhance driver education. Its development focused on three key components: environment design, gamification elements, user interaction and system architecture. The prototype was built using the Unity Game Engine with 3D assets modelled in Maya and integrated into a VR interface compatible with Oculus. The main objective of the prototype was to provide learner drivers with a realistic, safe, and motivating training environment that mirrors actual licensing test conditions while encouraging repeated practice and self-improvement.

4.1 ENVIRONMENT DESIGN

The virtual environment was developed to closely replicate the structure and layout of a standard Malaysian driving test circuit, thereby providing learners with an authentic representation of the tasks and maneuvers required during licensing examinations. The design emphasized realism and procedural accuracy to ensure alignment with national testing standards. Road segments were carefully modeled with appropriate lane markings, speed limit indicators, and directional arrows to simulate realistic traffic layouts and regulatory cues. Parking zones and junction areas were configured to reflect actual test components, including three-point turns, slope starts, and parallel parking manoeuvres. In addition, environmental elements such as lighting effects, surface textures, trees, barriers, and road signage were incorporated to enhance visual fidelity and strengthen the immersive quality of the simulation. Collectively, these design features aim to create a realistic and pedagogically meaningful training environment that supports skill acquisition and procedural familiarity.

4.2 GAMIFICATION ELEMENTS

Gamification was systematically integrated into the Learn2Drive system to enhance learner engagement and sustain motivation throughout the training process. Drawing upon principles of intrinsic and extrinsic motivation, the prototype transformed conventional driving practice into an interactive experience characterized by measurable progress, performance tracking, and reward-based reinforcement. A structured scoring system was implemented to allocate points for accurate parking, proper turning techniques, appropriate speed control, and adherence to traffic regulations. In addition, real-time feedback mechanisms provide immediate notifications when users committed errors, such as failing to signal, lane deviation, or exceeding speed limits, thereby promoting corrective learning and self-regulation. Achievement badges were also introduced to recognize the mastery of specific competencies, including parallel parking, hill starts, and penalty-free session completion. Collectively, these gamified elements encouraged repeated practice, facilitated self-assessment, and supported goal-oriented learning behaviours. This design approach aligns with existing research indicating that gamified educational systems can enhance learner motivation, persistence, and skill acquisition (Ramos et al., 2024; Chen, 2020).

4.3 USER INTERACTION AND CONTROLS

User interaction within Learn2Drive was designed to be intuitive and immersive, minimizing technical barriers and allowing learners to focus on driving tasks. Learners navigated the environment using a VR headset for spatial awareness and handheld controllers simulating steering wheel and pedal actions. This setup replicated real driving motions, coordination and enhanced the sense of presence. The user interface (UI) kept simple and functional, displaying only essential information such as speed, indicators, and feedback messages. Menu navigation was gesture-based, ensuring that learners could transition between sessions or review their performance without removing the headset.

4.4 SYSTEM ARCHITECTURE

The Learn2Drive prototype was designed using a modular system architecture to facilitate independent development, testing, maintenance, and future expansion of core components. This modular approach enhances system scalability and flexibility, enabling the integration of advanced functionalities such as AI-based driving performance analysis and cloud-based learner progress tracking in subsequent iterations. The architecture consists of four primary modules. The Simulation Module is responsible for vehicle dynamics, physics-based motion modelling, and interactions with the virtual environment to ensure realistic driving behaviour. The Gamification Module manages scoring algorithms, real-time feedback mechanisms, and achievement tracking to support motivational design objectives. The User Interface Module governs in-game menus, dashboards, and performance summaries, ensuring intuitive navigation and clear information presentation. Finally, the VR Integration Module handles three-dimensional rendering, head tracking, and controller synchronization to maintain immersive interaction and spatial consistency within the virtual environment. Together, these modules form a cohesive and extensible system framework that supports both technical robustness and pedagogical effectiveness.

4.5 PROTOTYPE INTERFACE OVERVIEW

This subsection presents the main visual components of the Learn2Drive prototype, including the road environment, main menu interface, and driving mode display. These visuals highlight the integration of immersive simulation and gamified feedback.

Main Menu Interface

Road Sections

Driving VR Mode (User Perspective)

Feedbacks

Achievement Screen

Badges & Scoring

Figure 2: Interface of Learn2Drive

The Learn2Drive prototype successfully integrates immersive VR simulation, gamified learning mechanics, and an intuitive user interface into a cohesive educational platform. Through iterative development and testing, the system demonstrated the potential to enhance learner engagement, confidence, and performance during simulated driving sessions. Its modular architecture further supports scalability, making it a promising foundation for future innovations in driver education technology.

5. RESULTS AND DISCUSSION

The Learn2Drive prototype was evaluated through observations, informal interviews, and post-session reflections with twenty novice learners preparing for their licensing examinations. The evaluation focused on learner confidence, motivation and engagement, understanding of test procedures, usability and system adaptation, and system limitations, as summarized in Table 1.

Table 1: Summary of Evaluation Aspects for the Learn2Drive Prototype

Evaluation Aspect	**Description**	**Supporting Studies**
Learner Confidence	Confidence affects driving performance and test outcomes. VR allows safe, repeated practice to build self-efficacy and reduce anxiety.	[(Noor & Ullah, 2024); (Bosch-Barceló et al., 2024)]
Motivation & Engagement	Gamification elements (e.g., scoring, rewards, feedback) enhance enjoyment and persistence in learning.	[(Ramos et al., 2024); (Chen, 2020)]
Understanding of Test Procedures	VR environments improve procedural knowledge and help visualize test rules and tasks.	[(Pears et al., 2023); (Yang & Oh, 2022)]

Usability & Adaptation	Usability influences user satisfaction and learning efficiency, especially for VR-based systems.	[(Hewko & Shaigetz, 2024)]
System Limitations	Identifying limitations (e.g., hardware cost, realism) informs future improvement and scalability.	[(Zhao & Li, 2022)]

5.1 QUANTITATIVE & OBSERVATION FINDINGS

Observation and learner performance data demonstrated clear improvements across all evaluation aspects. As illustrated in Figure 3, participants showed increased confidence and reduced anxiety while performing simulated driving tasks. Learners benefited from being able to repeat maneuvers in a risk-free environment, which contributed to greater comfort and readiness before attempting real-world driving sessions.

In terms of engagement, learners responded positively to the scoring system, instant feedback, and badge-reward features, which encouraged repeated attempts and sustained motivation. Observations also indicated a high level of attention and consistency during simulation sessions, with participants demonstrating continuous improvement in driving precision and procedural compliance.

Usability feedback from post-session reflections showed that learners adapted quickly to the VR controls, found the interface intuitive, and appreciated the realism of the simulated driving track. Minor challenges observed included a brief learning curve during initial interaction with VR hardware and occasional hand-controller misalignment, though these did not significantly hinder learning. Overall, these results confirm that Learn2Drive effectively enhances confidence, engagement, and skill preparedness, supporting the potential of VR and gamified approaches in driving education.

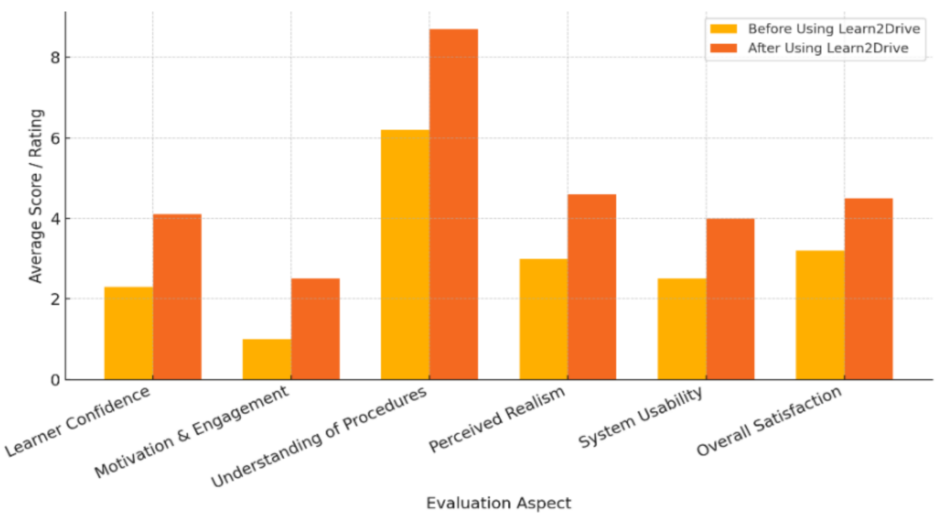

Figure 3: Learner Performance and Perception Before and After Using Learn2Drive

5.2 INTERVIEW FINDINGS

To complement the observational results, semi-structured interviews were conducted with ten participants. Thematic analysis was used to categorize responses according to the same evaluation dimensions used in system testing: confidence, motivation and engagement, understanding of test procedures, usability and adaptation, and system limitations. The interview insights reinforced the observed outcomes and provided additional qualitative depth as in Table 2.

Table 2: Interview Findings Based on Evaluation Aspect

Aspect	Interview Insight	Sample Quote
Learner Confidence	Learners felt more confident and less anxious after practicing difficult tasks in a safe VR environment.	"I was scared to try slope and parking in real life, but VR practice made me confident."
Motivation & Engagement	Scoring, badges, and feedback made learning fun and encouraged repeated practice.	"I kept trying to beat my score; the badges motivated me."
Understanding of Test Procedures	VR helped learners understand the test layout and required steps before attempting it physically.	"Now I know exactly where to stop and signal on the test track."
Usability & Adaptation	Users found the system easy to use and quickly adapted to the VR controls.	"The VR controls felt natural after a few minutes."
System Limitations	Some struggled with initial VR adaptation; wished for traffic scenarios and easier device access.	"It would be better with real traffic; not everyone has VR."

Interview responses highlighted those learners felt more confident handling critical driving tasks (e.g., slope and parking) after repeated VR practice. Gamified elements were frequently mentioned as motivating factors, encouraging learners to improve scores and complete challenges. Participants also described the VR environment as realistic and useful for visualizing the test circuit and understanding required procedures. Some limitations raised included the absence of live traffic, limited environmental variation, and dependency on VR hardware availability. These insights provide direction for future system enhancements.

5.3 DISCUSSION

The combined observational and interview results demonstrate that Learn2Drive successfully enhances learner confidence, motivation, and understanding of licensing test requirements. The system's intuitive interface and immersive design supported strong usability outcomes, while gamification elements promoted persistence and enjoyment in learning. These outcomes correspond with existing research indicating that VR training environments improve self-efficacy and procedural competence, while gamified features foster motivation and learning persistence (Noor & Ullah, 2024; Ramos et al., 2024). Although minor challenges were noted like hardware access and the absence of dynamic traffic; learners overwhelmingly viewed the system as a beneficial complement to traditional driving lessons. In summary, Learn2Drive demonstrates strong potential as a scalable, learner-centered VR solution for enhancing modern driver training in Malaysia.

6. CONCLUSIONS AND FUTURE WORK

This study presented Learn2Drive, a VR-based gamified prototype designed to enhance driver training by improving learner confidence, motivation, and familiarity with test procedures. The system successfully provided an immersive and engaging practice environment, allowing novice learners to perform repeated manoeuvres safely and gain procedural understanding before real-world driving.

Although the prototype achieved positive outcomes, limitations were observed, including hardware accessibility, initial user adaptation to VR controls, and the absence of dynamic traffic environments. Future work will focus on integrating AI-based virtual coaching, expanding driving scenarios to include complex traffic and weather conditions, and improving system accessibility for broader institutional use. In summary, Learn2Drive demonstrates significant potential as an innovative, technology-enhanced driver training tool and represents a meaningful step toward modernising Malaysian driving education through immersive and gamified learning.

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