A Train Driving Simulator to Enhance Railway Technology Student's Learning Experience Using Prototype Method and OpenBVE

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Abstract

A Train Driving Simulator is a software application that tries to replicate the experience of operating a train. This unique equipment minimizes the expense of using actual rolling stock to teach future railway staff. The research aims to create a Train Driving Simulator with OpenBVE for Railway Technology students. The research focused on making a simulator that simulates the feeling of driving a train, which involved detailed physics modeling and control of the train. The simulator was built to be user-friendly and accessible, with features such as the 3D representation of the LRT Line 1 route and its compact, portable architecture. The simulator was built from commercial off-shelf parts and tested for usefulness, safety, and durability. The simulator's performance was tested using the TUP evaluation metrics. The research aimed to enhance the learning experience of students undergoing railway technology by providing on-site training in operating a train. The simulator will likely provide students and instructors with maximum benefit in courses like Railway Signaling, Rolling Stocks, and Railway Facilities.

1. Introduction

A train driving simulator is a software application replicating the experience of operating a train. This customized equipment minimizes the expenses of using genuine rolling stock to educate prospective railway staff.

A simulator often encompasses many characteristics that emulate the real-world environment and accurately simulate physics to duplicate train operations. Users may precisely manage the train's speed, breaking, and operation of other onboard devices. They may also investigate alternative train routes and use this simulator to conduct studies to develop new railway networks.

The railway course at the Technological University of the Philippines currently lacks railway-related instruments, which is a substantial obstacle to providing students with practical experience in the railway sector. This obscures the students' comprehension of train controls and other aspects of train operation.

The Train Driving simulator will provide our railway students and teachers with teaching material for practical experience in Basic Train Driving. This will also pertain to the subjects designated as Railway Signaling, Rolling Stocks, and Railway Facilities. We aim to enhance the educational capacity of our railway program by supplying train-driving simulator equipment to enable our institution to produce proficient students and to acquaint them with railway train control equipment.

The researchers want to develop a train simulator using the OPENBVE application to impart fundamental train driving concepts to railway technology students at the Technological University of the Philippines - Manila.

1.1 Literature Review

Simulations model present or future systems. It may test scenarios or process improvements to guide decisions. Combine with VR for immersion. Simulations may test theories, train personnel, improve processes, boost performance, and even be enjoyable in games. Scientific models can show how actions and events affect customers. System simulation may be utilized for conceptual, developed, risky, or unavailable systems. User-friendly simulation software shows processes. This visual simulation should contain time, rules, resources, and limits to represent the real process. It may represent a busy supermarket and consumer activity that affects supply chain, shop floor, and staff decisions. Simulation can also be utilized in manufacturing line segments for process interactions. Showing how the system works might inspire innovative solutions and performance-enhancing ideas. Imitating an event-based system is conceivable. To repeat a method, use a flowchart. Simulation works for processes or equipment with random inputs, changeable factors, or temporal changes. Consumer needs, consumption, and product supplies were unpredictable at our previous supermarket. Simulation can highlight complex, changing, dynamic systems that are hard to define. Simulations help understand and improve complicated systems. It aids users in simulating systems, testing situations, and enhancing processes in a safe environment (Banks et al., 2010). This aids decision-making and performance optimization. Immersive simulations, particularly VR ones, may improve user engagement and learning (Tako & Robinson, 2010). Immersive VR simulations are useful in healthcare instruction (Li et al., 2021).

Simulations are used in many disciplines. They may be used for staff training, hypothesis testing, process optimization, and video game amusement. Simulations allow scientists to model systems and show how actions affect consumers (Robinson, 2004). Simulations are useful for envisioning new systems, assessing current ones, and examining risky or inaccessible systems (Pidd, 2004). Epidemiology simulations analyze infectious disease propagation and assess public health measures (Ferguson et al., 2006). User-friendly simulation software with visualization helps improve simulations. These graphic simulations mimic real-world processes, including time, rules, resources, and limits. A simulation might simulate a busy supermarket and its customers, showing how they affect the supply chain, shop floor, and personnel actions (North & Macal, 2007). Simulation is also used in manufacturing line segments to evaluate process interactions and find improvements. Visualizing complex systems helps comprehend their behavior and find better solutions (Borshchev & Filippov, 2004). Event-based systems may be simulated using a flowchart to reproduce a process. This benefits processes or equipment with variable factors, random inputs, or time-dependent changes. Simulation helps supermarkets analyze and manage uncertain consumer needs, use trends, and product inventories. Simulations can illuminate the complex, changing, and dynamic systems that are hard to explain or analyze (Law & Kelton, 2000). By revealing these systems' inner workings, simulations may spark innovative solutions and performance improvements.

Full cabins match the original train cabin. The cabin simulator's sound system accurately depicts vehicle noises and surroundings. Complete side window and virtual side mirror modeling is possible with 180-degree visibility. Every cabin simulator has a train driver's chair and vehicle-specific footrests. The train driver's responsibility for locomotive components, shallow voltage boards, and a driver's assistant's station are often shown on a tablet in the cabin. An intercom and GSM-R virtual radio are in the cabin—guaranteeing flexible train instructor/dispatcher communication (Motion Systems, 2022). Train cabin simulators simulate safe train operation. These simulators frequently match a genuine train cabin's appearance, feel, and sound for maximum realism (Motion Systems, 2022). This involves recreating the cabin layout, employing original controls and instruments, and giving the operator accurate audio-visual input. Visual integrity is crucial to immersive simulations. This requires precisely replicating the train cabin's driver's seat, controls, and displays (Wagner & Ohlsson, 2014). High-resolution screens and projection systems can simulate trackside scenery, signals, and other trains with a broad field of vision. Some simulations use motion platforms to provide operators with tangible input, boosting immersion (Chung et al., 2019). A compelling simulation requires proper sound design and visual accuracy. This involves replicating train engines, wheels, other mechanical components, and wind, rain, and track noise. Auditory cues provide presence and realism, connecting the operator to the simulated world (Ohlsson, 2012). Modern train cabin simulators also frequently include functions beyond visual and audio imitation. This includes simulating equipment failures, bad weather, and emergencies. Simulators may increase performance and decision-making by exposing learners to these difficult circumstances in a safe setting (Stevens & Weal, 2001).

CPU, monitor, and microprocessor input device in a portable train simulator. The first program reacts to input device controls and displays control stand indicators. Upon control inputs, another program shows a data file-navigated track. Virtual control allows train simulator movement. A train's present and previous operating characteristics may be shown based on the input source. Operators may change recorded conditions and attempt new train management approaches by switching between playback and simulation modes. Railway training and operational analysis increasingly need portable train simulators. These compact systems are more accessible and flexible than full-scale simulators, allowing training in numerous situations (Hawthorne et al., 2002).

Simulator software is crucial for realistic training. The prototype software displays control stand indications and responds to device inputs, imitating train cabin operations. The operator's control inputs dynamically control a virtual track environment created by secondary software. This allows trainees to experience different situations and improve their responses (Iwnicki, 2006). Portable train simulators must record and recreate operating data. This feature lets operators evaluate past performance, identify key events, and identify development opportunities (Ahlstrom et al., 2006). By switching between playback and simulation modes, trainees may adjust recorded situations and try different train management tactics, improving their understanding of operating procedures and decision-making.

A compact simulator shows that smaller simulators outperform desktops. These have a separate driving seat, controls, and a bigger display screen or many screens to improve the driver's eyesight. Compact simulations are valuable for early research and intense education (Pettinger, 2023). Installing a compact simulator anywhere is easy. Wheeled desk. Real and virtual controls. Respect station ergonomics. Stereo/headphones and accurate railroad sound. Communication between students and professors. Same characteristics as other simulators. Fiber with internal reinforcement makes structural glass. Show objects outside the desk with the simulated train—innovative front-display TV (Railway Simulators, 2022).

Compact train simulators provide realism and practicality and are effective driver training and evaluation tools. Full-scale simulators are the most realistic, while smaller simulators are cheaper and more accessible for early training and skill improvement (Pettinger, 2023). These simulators contain a custom driving seat, accurate controls, and an extensive display system, often with many screens to enhance the driver's eyesight (Railway Simulators, 2022). Utility and ergonomics are prioritized in small simulators. These simulators help trainees learn faster by simulating a train cab's layout and atmosphere. Adjustable seating, realistic controls, and accurate sound modeling make training more immersive. Fiber-reinforced structural glass makes these simulators solid and durable (Droste et al., 2020). Tiny simulators' portability allows for deployment in numerous contexts. They may be easily integrated into classrooms, training facilities, or mobile units, improving simulation-based training. Businesses with limited space or resources benefit from this flexibility. Communication technologies improve student-teacher engagement, providing quick feedback and instruction (Caldwell et al., 2021). Research suggests tiny simulations can teach basic driving, situational awareness, and decision-making skills. The condensed design and user-friendliness make them ideal for repeated practice and customized training exercises, improving performance and operating efficiency.

1.2 Objective of the Study

The study's main objective is to develop a Train Driving Simulator using OpenBVE for Railway Technology students.

Specifically, the study aimed to:

1. Design a Train Driving Simulator with the following features;
    a. A 3D-ready route which will be based on the LRT Line 1 Route
    b. A 40-inch screen for an immersive view experience
    c. A standard set of controls of basic train driving controls using the Rail Driver Controller
    d. The module of the Simulator is compact and can be movable anywhere
    e. Proper train breaking and positioning in Railway Station Platforms and following proper stopping locations by following wayside signs/signals
2. Build the prototype according to the specifications.
3. Test and improve the prototype regarding functionality, safety, and durability.
4. Evaluate the prototype's performance using the standard TUP evaluation.

2. Research Methods

This research methodology describes developing a train driving simulator using a prototyping approach. The simulator aims to provide railway technology students with a realistic and immersive experience, enabling them to learn basic train driving controls and operations.

Requirements Gathering and Analysis:

- Identify the needs and requirements of the simulator, focusing on basic train driving controls and functionalities.
- Analyze existing train driving simulators and their features to gather insights and best practices.

Prototype Design:

- Develop an initial design for the simulator, including hardware and software components.
- Select appropriate tools and technologies, such as OpenBVE software, Rail Driver controller, and a 40-inch LCD TV for the display.
- Consider the design of the simulator module, ensuring it is compact, movable, and user-friendly.

Prototype Development:

- Build the initial prototype of the simulator based on the design specifications.
- Integrate the hardware and software components, ensuring proper communication and functionality.
- Develop the 3D-ready route based on the LRT Line 1 Route, including train controls, physics, and environmental elements.

Prototype Evaluation:

- Test and evaluate the prototype with railway technology students and instructors.
- Gather feedback on the simulator's functionality, usability, and effectiveness in teaching basic train driving.

Prototype Refinement:

- Based on the evaluation feedback, refine the prototype to address any issues or improve its functionalities.
- Make necessary modifications to the hardware and software components to enhance the user experience and learning outcomes.

Iteration and Finalization:

- Repeat the prototype development, evaluation, and refinement process until the simulator meets the desired requirements and performance standards.
- Finalize the design and development of the train driving simulator, ensuring its functionality, safety, and durability.

Evaluation:

- Evaluate the final prototype using the standard TUP evaluation system, including additional feedback from railway personnel.
- Assess the simulator's performance based on functionality, aesthetics, workability, durability, economy, safety, and marketability criteria.

This prototyping methodology allows for iterative development and continuous improvement of the train driving simulator, ensuring it effectively meets the learning objectives and provides a valuable training tool for railway technology students.

3. Results and Discussion

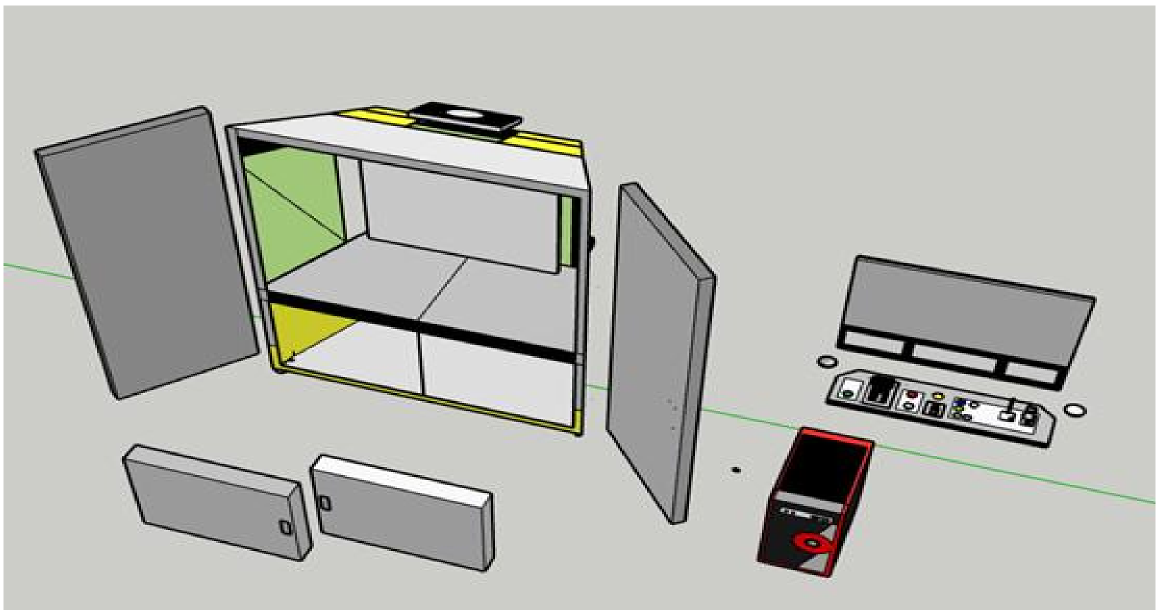

Fig. 1 Exploded View of the Train Simulator Module

Figure 1: Exploded view of the Train Simulator Module It is a system diagram that makes explicit the relationship using simple labeled blocks representing single or multiple item concepts connected by lines. The Train Driving Simulator was designed and developed as a prototype to enhance the learning experience of Railway Technology students at the Technological University of the Philippines—Manila. The simulator filled the void of railway-specific instruments in the course and gave students a hands-on experience of basic train driving concepts.

The simulator was developed using a prototyping approach, with iterative design and development phases based on feedback from students and instructors. A compact and movable module made of marine plywood houses a Rail Driver controller, a computer monitor, and a 40-inch flat-screen TV for an immersive viewing experience. The simulator used the OpenBVE software, an open-source train simulator that allowed the creation of realistic 3D routes and train control simulation.

The Train Driving Simulator successfully simulated basic train driving controls, including the master controller, forward, neutral, and reverse controls, train doors, train braking controls, and familiarization with the train control panel. The simulator provided the students with the experience of having a realistic train operation that was identical to train physics and real-world environments like the LRT Line 1 route.

The prototype of the Train Driving Simulator was assessed using the standard TUP evaluation system with feedback from railway personnel. These evaluation criteria were based on functionality, aesthetics, workability, durability, economy, safety, and marketability. The tool seems to have gained satisfied comments from students and instructors for its effectiveness in teaching primary train-driving concepts.

4. Conclusions

The simulator prototype met the study's objectives by providing a realistic, immersive train driving experience that simulated basic controls and operations. A prototyping approach enabled iterative design and development, thus ensuring that the simulator effectively addressed the students' learning needs.
The research findings and evaluation results conclude that the Train Driving Simulator is an effective learning experience for Railway Technology students. Indeed, the simulator's simulation of the actual train controls, physics, and real-world environment gives students a strong hands-on experience related to the classroom instructions; additionally, the simulator's compact and movable design allows its flexible application in diverse learning settings.

Based on the research outcomes, the following recommendations are made:

1. Further development of the Train Driving Simulator to include advanced train driving features and controls.
2. Integration of additional 3D routes based on other railway lines in the Philippines.
3. Evaluation of the simulator's long-term impact on student learning and performance in railway-related courses.
4. Exploration of potential applications of the Train Driving Simulator in other educational and training settings.

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