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Research Results

Heavy Equipment Simulator Training Optimization

This project performed research to provide an optimized heavy equipment simulator training for use by California Department of Transportation (Caltrans) maintenance.

Maintenance

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Project Title: Equipment Simulators

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WHAT WAS THE NEED?

Caltrans needs to provide the best available training to its Maintenance personnel, particularly those operating heavy equipment. Previous research conducted under Task ID 3833 showed that heavy equipment simulators are beneficial to Caltrans' training efforts. These simulators can be used to expose employees to machines before any on-iron training with real equipment, providing a safer and more affordable environment. Caltrans wants to expand and optimize its training program with simulators. In addition, Caltrans seeks to understand return on investment, training effectiveness, and best training practices.

WHAT WAS OUR GOAL?

The goal of this research was to evaluate the effectiveness of heavy equipment simulator training and see how best to improve Caltrans' training efforts.

WHAT DID WE DO?

In this research, the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center at the University of California (UC) Davis conducted human subject research using a John Deere/CM-Labs simulator and fully immersive Caterpillar simulator with its optional Virtual Reality (VR) glasses. A CM-Labs minimal immersion desktop simulator system was also used by UC Davis student volunteers to test training routines before being performed by Caltrans trainers on Caltrans premises. The results of the study were expected to allow the quantification of factors such as the training effectiveness ratio. AHMCT provided training schedules, tasks, and logistics recommendations for Caltrans' Division of

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Maintenance's training program. The results were compiled in a final report summarizing the study results and future recommendations.

WHAT WAS THE OUTCOME?

Heavy equipment simulator training was found to have a positive effect when combined with on-iron training. During this research, the AHMCT team:

- Collected data showing that trainees with prior simulator experience achieved higher material removal rates (MRR) during on-iron operations, confirming that simulator training accelerated operational competency.
- Determined that paired or small group simulator yields a significantly higher net confidence gain compared to solo training, establishing that peer-observation and collective discussion substantially optimize the simulator training workflow.
- Demonstrated that, while VR headsets marginally boost raw confidence, they degrade overall performance and induce physical side effects like motion sickness.
- Documented the performance benefits of multi-session simulator training while identifying that minimizing the time delay between simulation and on-iron training is critical to mitigating confidence decay.
- Established engineering and operational requirements for Caltrans mobile environments, identifying desktop simulators as a viable option when training in rural areas.
- Developed targeted small group engagement worksheets to maintain student focus during downtime and mapped simulation modules directly to relevant on-iron skills.

WHAT IS THE BENEFIT?

The research provides information that may allow Caltrans to make more informed decisions on the return on investments in heavy equipment simulators and design of training programs with a mix of on-iron and simulator training. This research may lead to cost savings on training equipment as well as a testing workflow that better protects trainees from hazards and injury while operating real equipment.

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