

Low-Cost “Good Enough” VR Trainers for Maintenance Technicians

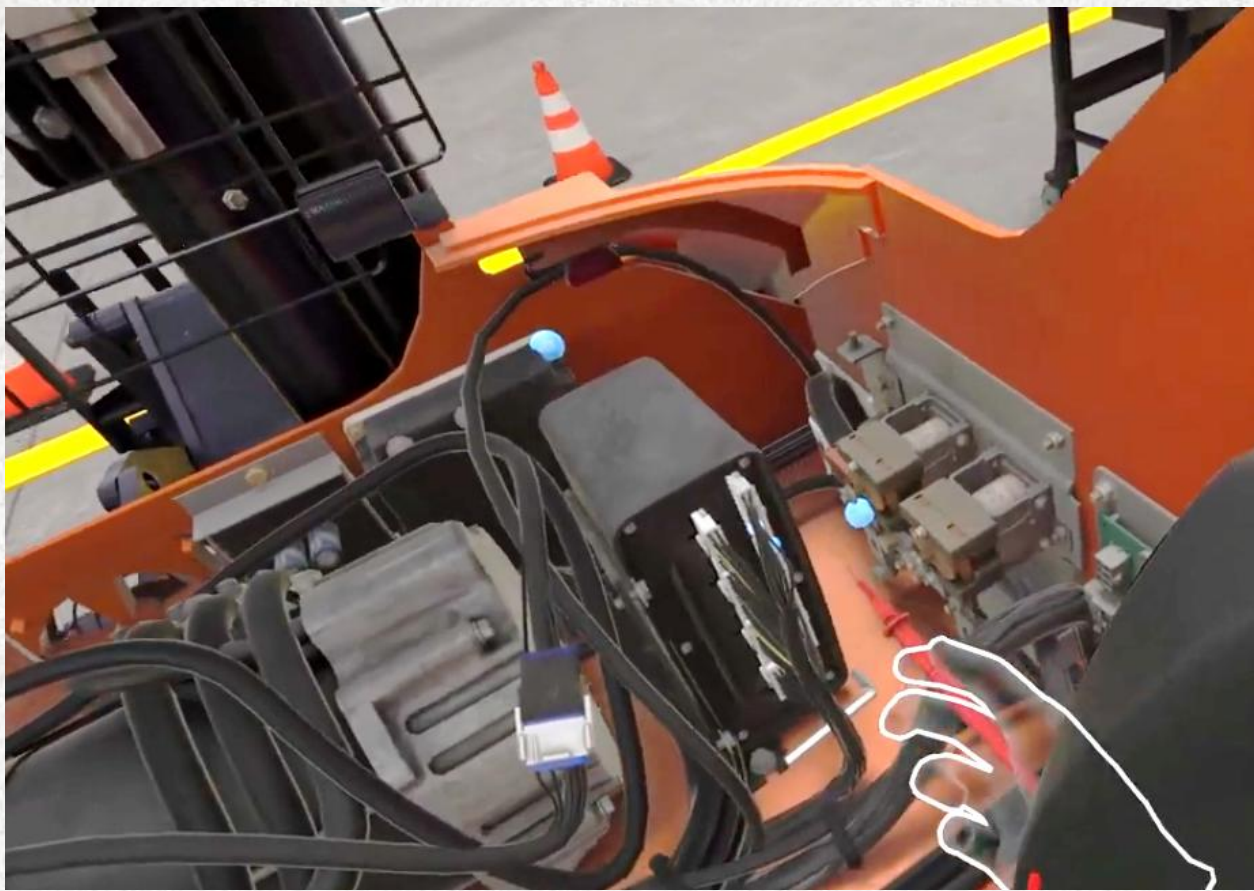
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Cyber-Physical, Knowledge Transfer, Training

BACKGROUND

- High realism VR simulators are cost prohibitive for wide adoption.
- Not clear that VR realism correlates with learning effectiveness.
- Low-fidelity VR may possibly be good enough for experienced technicians to learn new tasks anytime, anywhere.



Source: <https://www.youtube.com/watch?v=fzlaPdbIUvU>

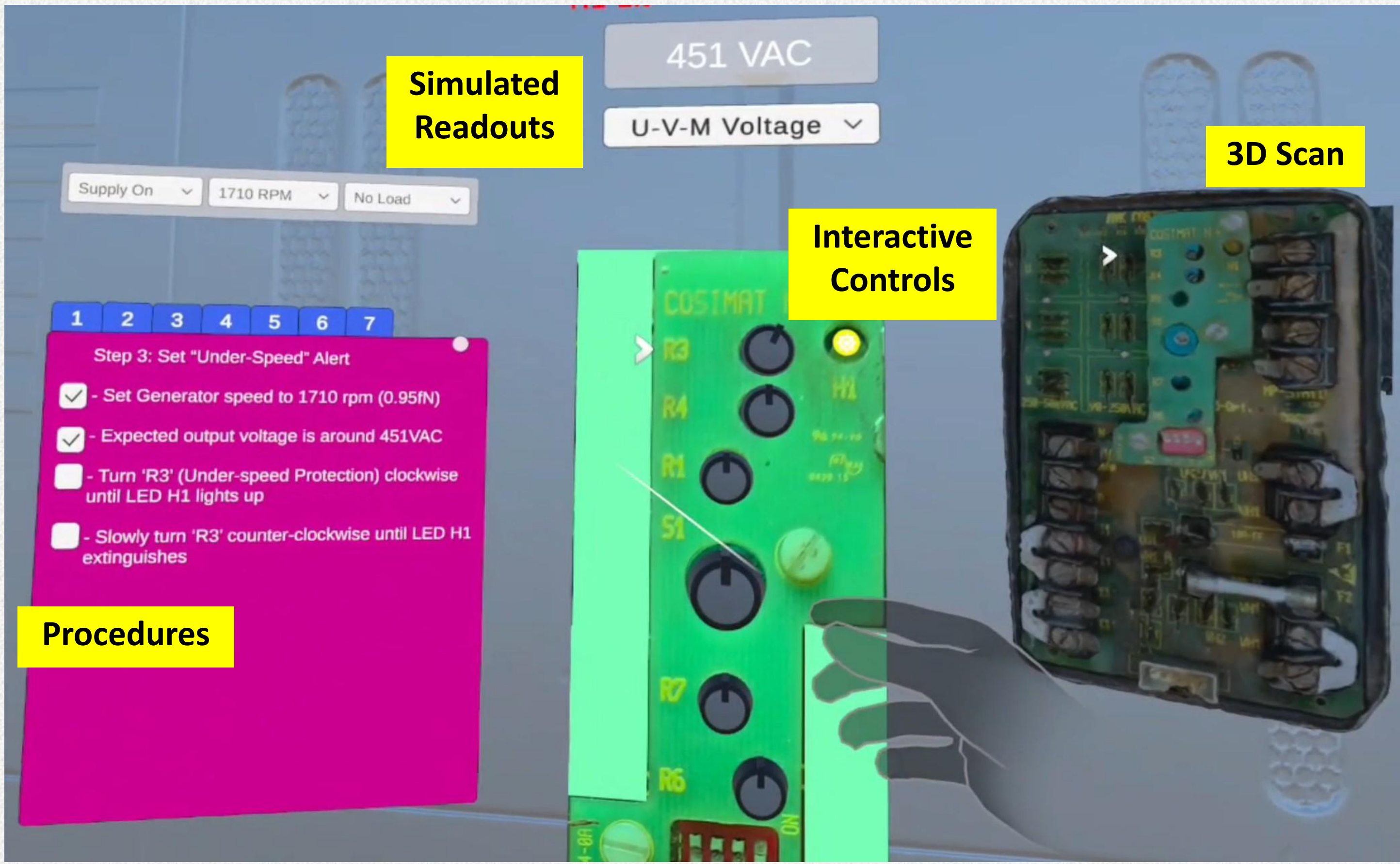
Research Gap

- Limited research on skills transfer or retention for experienced learners.

METHODS

Design a Low-Fidelity VR

- Built a **VR Trainer in Unity®** to simulate a calibration task.
- **Preserved** task affordances, procedural cues (e.g. equipment layout, controls, readouts etc.);
- **Omitted** high sensory details (e.g. photorealistic rendering, physics-based interactions etc.).



Measure Learning Effectiveness

- **NASA Task Load Index** to capture cognitive workload.
- **System Usability Scale** to capture acceptance level.

CONCLUSION

- Lightweight low-fidelity VR solutions can enable urban infrastructure technicians to learn new procedural tasks better than traditional methods (e.g. On-the-Job training etc.).
- Low-cost VR trainers provide safe-to-fail training environment, especially for honing skills on high-energy systems (e.g. generators, elevators etc.), without disrupting live systems.

AIM

- Identify “goldilocks zone” of VR fidelity that best enables experienced technicians to acquire new procedural skills.



Source: <https://www.techradar.com>

FINDINGS

- Conducted trials with skilled technicians (N=18) to capture retention of procedural- and scenario-based knowledge.
 - with prior work experiences (N=3).
 - with prior VR gaming experiences (N=8).

Accuracy & Recall

Task Completion	Committed Error	Knowledge Recall
98%	8.5%	43.8%

- Achieved **good accuracy** despite given only a 5-min orientation of VR Trainer prior.
- **Knowledge recall** can be improved if technicians are primed to prepare for a recall test.

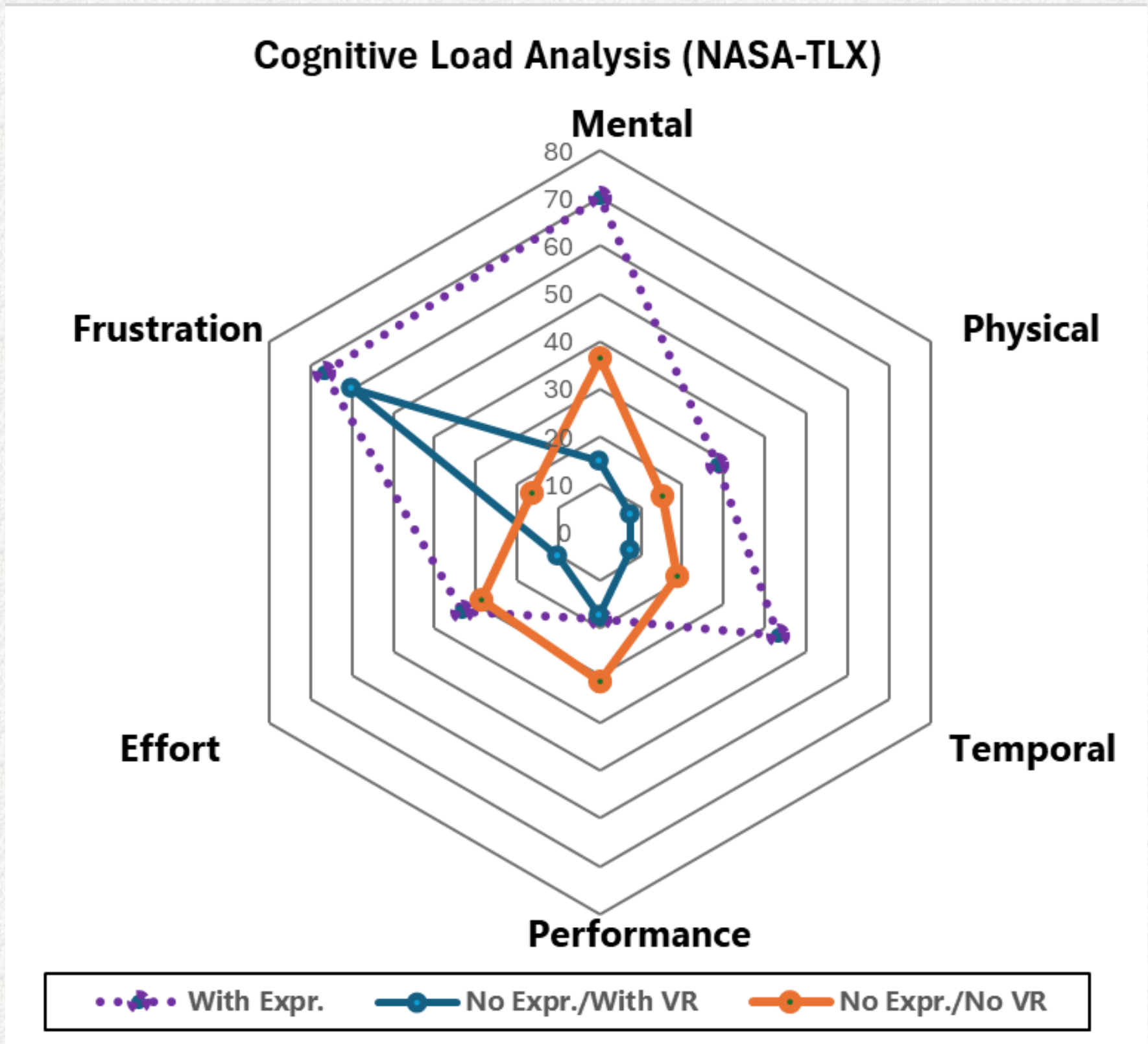
Cognitive Load & Usability

Cognitive Load

- Technicians with no prior experiences were comfortable using low-fidelity VR Trainer.
- This corresponded to observed willingness to deviate from prescribed procedures to explore system responses.

Usability Score

- Acceptable despite reduced fidelity.



Future Applications

- Extract low-fidelity models on-the-fly from expert practices and automate VR development by integrating process mining and runtime tooling.
- Extend low-fidelity knowledge models as “agentic skills” for digital cognitive assistants.



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