Evaluating System Usability, Workload Suitability, and User Experience of Game-Based Virtual Reality in Spaceflight Education and Training

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CHALLENGE:

- Space mission complexity poses a challenge in spaceflight education and training
- Orbiting spacecraft or satellites are elusive and difficult for a trainee to visualize
- Ground console streaming telemetry requires a steep learning curve

PROPOSED SOLUTION:

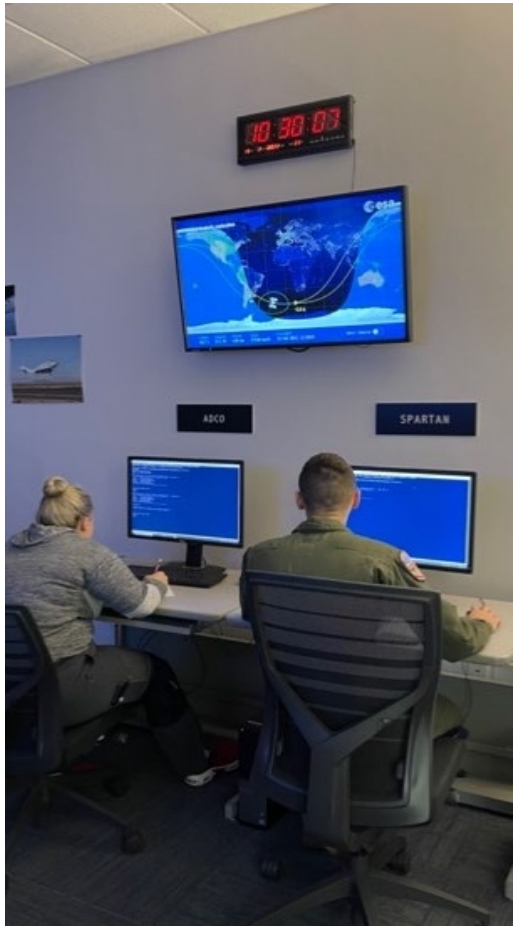
- Game-Based Virtual Reality (GBVR)
- **Game-based** instruction - enhanced learner **motivation**
- **Virtual reality** scenarios - prolonged **cognitive engagement**

TEST METHOD:

- Experimental study conducted in a university laboratory
- Three validated scales measured user perception of the GBVR training environment

TEST RESULTS:

- Results were satisfactory for all scales

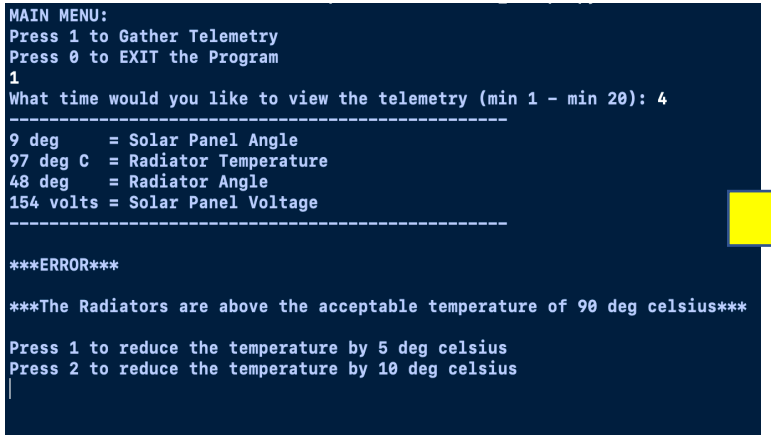


INTRODUCTION

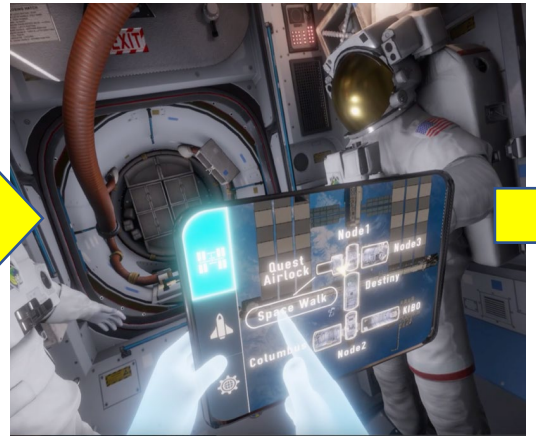
EXPERIMENTAL DESIGN

- 10 Participants (9 males and 1 female)
- Senior level college students enrolled in Spaceflight Operations
- Average age of participants was 23.4 years (SD = 2.7)

- Three 75-minute lectures (two weeks)
- 10-15 minute ground console simulation (Python, Microsoft office)
- 10-15 minute GBVR simulation (Mission ISS software, Valve Index VR Kit)
- 48 item questionnaire

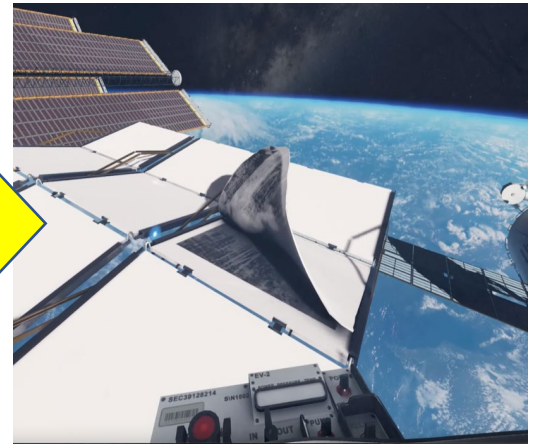


Ground Console Telemetry Readout



Spacewalk Decision Menu

Handrail Navigation to Site



Visual Inspection of Anomaly

METHODOLOGY

VALIDATED SCALES

System Usability Scale (SUS):

- Developed in 1986 (Usability.gov)
- Used to evaluate user perception of hardware devices and software applications

NASA Task Load Index (TLX):

- Developed in 1980s (NASA Ames Research Center)
- Subjective measurement of operator workload of human-machine interface

Game User Experience Satisfaction Scale (GUESS-18):

- Developed in 2020 (Keebler et al.)
- Derived from the GUESS-55 of 2016 (Phan et al.)
- Used to measure user satisfaction and enjoyment during gameplay

Table 1

Validated Scale Results and Accepted Benchmarks

Scale	*N*	Min	Max	Mean	*SD*	Accepted Benchmarks
SUS	10	67.5	90.0	81.8	7.6	68.0 = average score
GUESS-18	10	73.0	98.4	82.1	8.3	78.7 = popular game score [a]
NASA TLX	10	22.0	60.0	40.5	12.3	42.0 = mean score

Note. [a] An average GUESS-24 score of $M = 78.7$ resulted when examining six popular video games (Shelstad et al., 2019).

RESULTS (2021)

Research Summary:

- The integration and evaluation of GBVR in the classroom revealed satisfactory results
- Learner enjoyment and satisfaction were amplified, likely leading to increased motivation, prolonged cognitive engagement, and enhanced learning

Attributes for success:

- Proper laboratory setup – High system usability and suitable workload attributed to proven VR software and hardware setup
- Effective game mechanics - Overall user satisfaction ranked among six popular video games through proper in-game goal setting, reward, and immediate feedback

Future Research:

- A follow-up experiment will be performed with a larger sample size
- Develop knowledge test to measure skill retention with & without GBVR

CONCLUSION

Thank you for your attention!

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