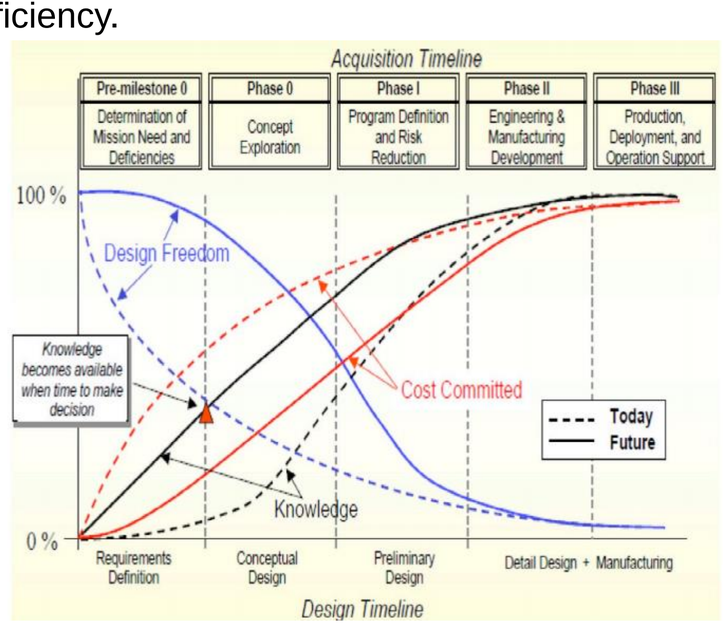
Evaluating Efficacy of VR Technology as a Validation Method for Spacecraft Habitat Design

Introduction

- Spacecraft habitat Design (SHD) is the process of creating a living and working space for humans outside of our Earth-based environment. The unique interdisciplinary requirements of spaceflight make design decisions both time consuming and expensive to evaluate, with severe consequences for poorly made decisions.

Research Gap

- With the recent advancements of Virtual Reality (VR) Technology many fields and disciplines that deal with design of engineering large complex designs have used them to their advantage. VR technology has not been traditionally been integrated into the SHD process, likely due to the long lead times associated with the SHD design cycle, along with the uncertainties and the unknown risks associated with performing evaluations using this yet-to-be proven approach. This thesis aims to investigate the practicality of the use of VR technology as part of a design methodology and evaluation of design, through the assessment of efficacy and efficiency.

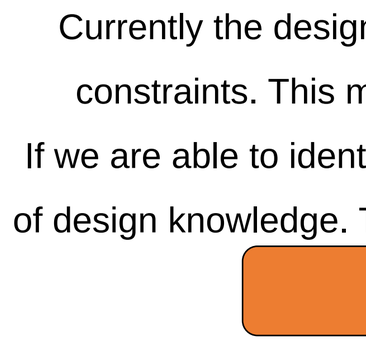


Currently the design freedom is low, usually bounded by time & cost constraints. This makes design knowledge based on assumptions. If we are able to identify possible errors early on because of our increase of design knowledge. Then we will be able to reduce costs in later phases.

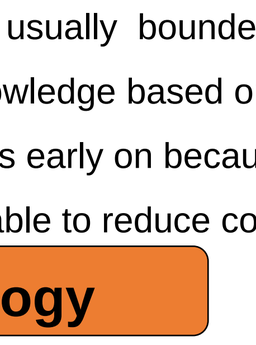
Methodology

- This will be done by examining the creation of stereoscopic renderings, walkthrough animations, interactive iterations, and quick demonstrations as explorations of mockups of SHDs through VR. Experimentation was done with two case studies where 31 participants explored two different SHDs in VR.

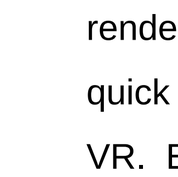
Case study 1: CEV Design



Case study 2: Small Lunar Habit Design



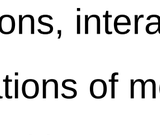
Hardware



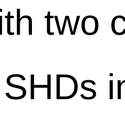
Oculus Quest 2

Asus ROG Gaming Desktop

Software



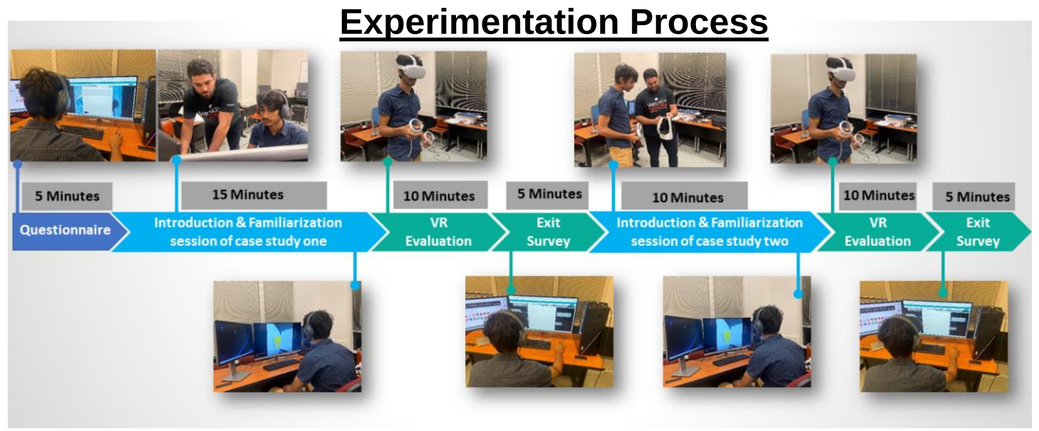
Blender

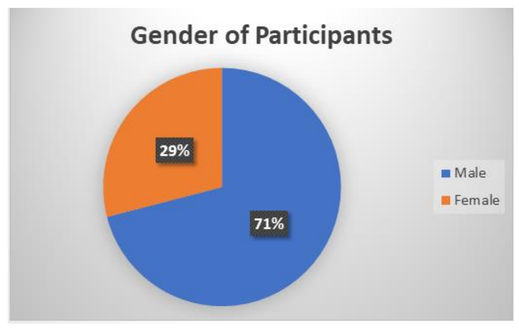


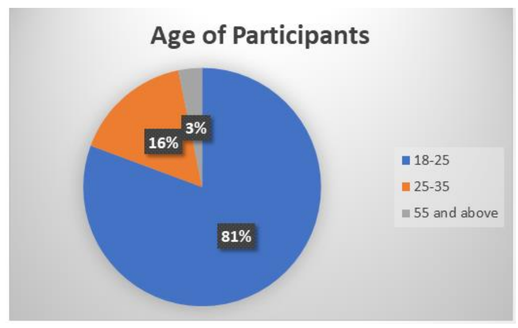
Twinmotion

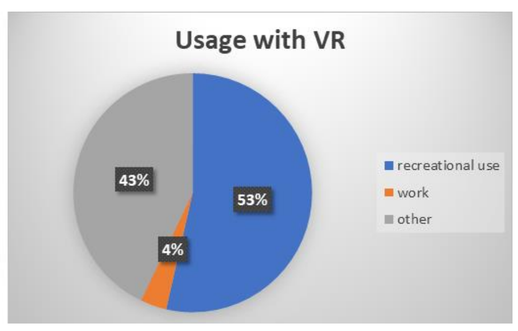
Unity 3D

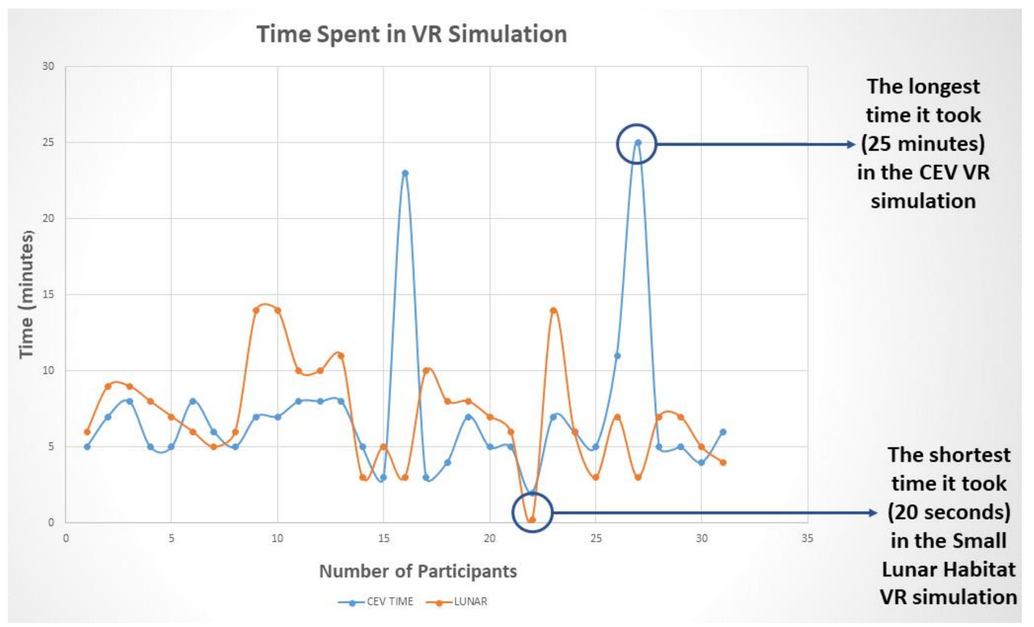
Experimentation Process



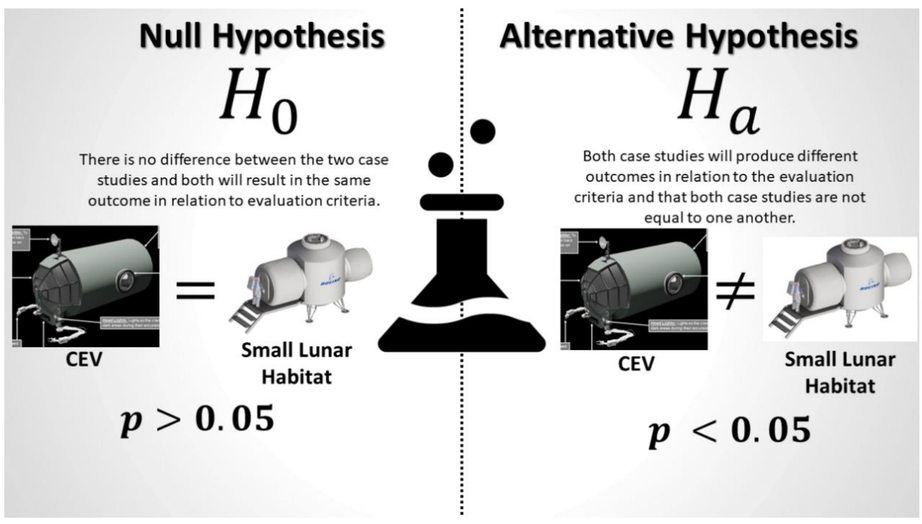








A two-sample t-test between the two VR simulations using the data obtained from the exit survey was employed to evaluate embodiment, locomotion, situational awareness, and usability between the CEV VR simulation and Small Lunar Habitat VR simulation.



Results

- This research aimed to investigate whether VR can yield the creation of a successful experience that exceeded the time constraints a common SHD mockup walk through (low efficiency) or create a limiting experience where interaction and functionality were not executed to meet the required standards when it comes to evaluating SHDs (low efficacy). Based on the quantitative and qualitative analysis of the two case studies, it was concluded that VR for SHD has high efficiency and efficacy for partial gravity SHDs and low efficiency and efficacy for microgravity SHDs

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Master Thesis
Fall 2021

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