

# FP5 - Project Report

## Group 3 – Home Construction

### 1. Problem Statement

Home designing is a complex and time intensive process, requiring professional expertise and iterative revisions as per the user's needs. Existing designs, visualization tools ranging from 2D blueprints to 3D renderings, often fail to provide users with a true-to-scale and immersive experience of architectural designs. This limitation creates barriers for multiple stakeholders that are present in the construction ecosystem. Homeowners struggle to visualize the spatial arrangement of conceptual houses, architects find it bit challenging to represent the design concepts, and real estate developers face difficulties presenting potential property configurations.

The core challenges include:

- Facade of interactive tools from traditional tools of design.
- Failure to provide the immersive context of proposed designs.
- Miscommunication between designers and their clients.
- Absence of intuitive and interactive components to represent designs.

Keeping these challenges in mind, our XR application endeavors to change the way home design is done, being more interactive, and user-friendly.

### 2. Project Objective

The primary objective of our application is to develop an innovative XR application that liberalizes home design by providing immersive design experience. Our project focuses on motivating users to design and visualize, as well as customize their future homes with clear ideas and fulfilling their basic requirements.

Project goals include:

- Creating an XR platform for home designing.
- Providing tools to place, modify and customize design components from the ground up.
- Providing immersive walkthrough experience of virtual home.

XR technology revolutionizes design by enabling live, interactive creation within a virtual environment. Its immersive visualization helps users make informed decisions before construction begins, reducing errors and improving outcomes. The application aims to bridge the gap between conceptual design and practical implementation, transforming approach for home design.

### 3. Target Audience

The application is intended for a broad audience throughout the residential construction ecosystem:

#### Homeowners and Prospective Buyers:

- Seeking to visualize and customize homes in a way that is suitable to their taste.

#### Architect and Designers:

- Providing tools to present ideas more effectively and collaborate with clients.

#### Construction Professionals and Developers:

- Providing an effective way of visualizing and pre-selling properties, making it easier to work together with all the team members.

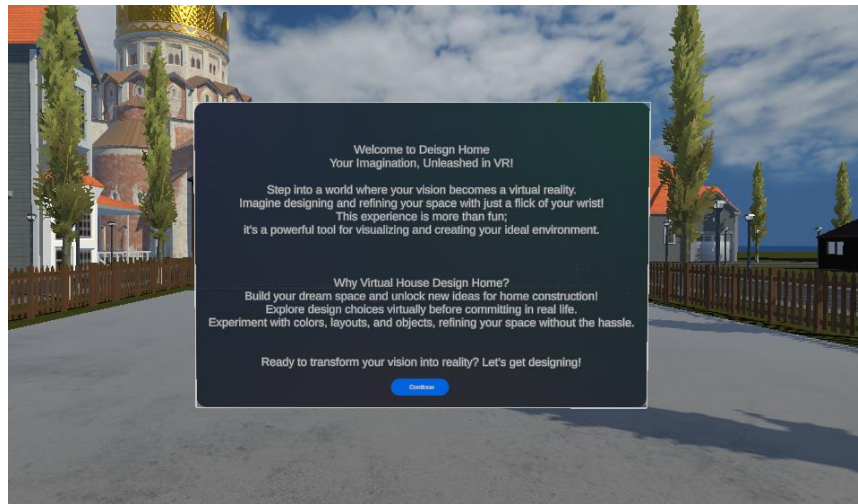
Our XR Application will help make users effective decisions and motivates creativity in home designing by fulfilling the unique needs of each group.

#### 4. XR App Description

This application uses the Meta XR All-in-One-SDK and provides the tools necessary for a user to construct their dream home.

##### Initial Instruction Scene

The app begins with an instruction scene that gives users an introduction to the application as well as provides instructions on how to navigate within the application. It also displays developer information.



*Image 1 – Introduction Scene*

##### Main Scene

This scene provides users with tools to design their home from the bottom up. The following are its key features.

##### 1. Environment

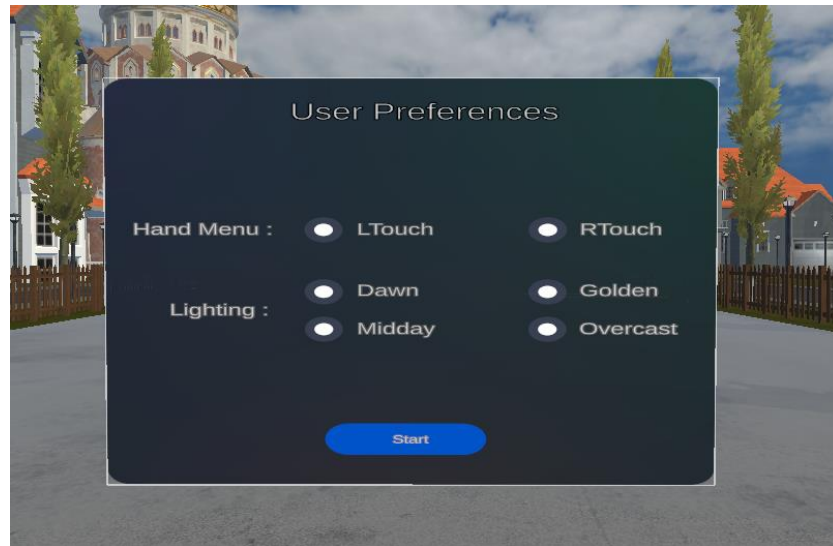
The environment features a city setting with designated construction plot. Users will be able to build their home on this platform.

##### 2. Navigation

Users can teleport to any area on platform using the right or left controller thumbstick. A reticle indicates their destination on the platform. The thumbstick can be moved along the x-axis to rotate about the scene. The application supports real walking as well.

##### 3. Preferences Menu

A preferences menu lets the users customize their environment, lighting and choose controller assignments. Users can choose which controller they wish to attach the hand menu to, making the other controller the active controller. The active controller will be used for navigation and selection of menu items as well as objects in the scene.



*Image 2 – Preferences Menu*

#### 4. Hand UI Menu

The hand menu is an intuitive scrollable UI menu created using Meta's UI Set that supports **Poke Interaction** and **Ray Interaction**. Any item on the menu can be selected but pressing the **Index Trigger** on the active controller. The menu has the following options and buttons:

- **Prefab Selection** – instantiates the chosen prefab in the scene.
- **Exterior Texture Selection** – applies the selected texture to exterior surfaces.
- **Exterior Color Selection** – provides an exterior color palate that can be applied to the exteriors.
- **Interior Texture Selection** – applies the selected texture to interior surfaces.
- **Interior Color Selection** – provides an interior color palate that can be applied to the interiors.
- **Instruction Button** – displays the user instructions.
- **Reset Scene Button** – lets users start over by deleting all objects on the platform.
- **Snapshot Button** – takes a snapshot of the user's current view and saves it to their local storage.



*Image 3 – Hand UI Menu attached to Left Controller*

## 5. Objects

The application provides the following objects for home construction:

- **Walls** – exterior, interior, corner wall, corner wall with window, exterior wall with door and exterior wall with window.
- **Floor**
- **Roof** - exterior roof and ceiling.

## 6. Object Interactions

Instantiated objects can be interacted with and grabbed using the **Ray Grab Interactor**. Below are the interactions the objects support.

- **Grabbing** – all objects can be grabbed using the Ray Grab Interactor using the index trigger button on the controller and moved to a desired location within the platform.
- **Duplication** – the current version of all objects can be duplicated by grabbing the object and pressing the A or X button, based on the active controller.
- **Deletion** – all objects can be deleted by grabbing the object and pressing the B or Y button, based on the active controller.
- **Rotation** - all objects can be rotated by hovering over them with the ray and moving the thumbstick on the active controller along the x-axis.
- **Moving objects above the ground** – roofs and ceilings can be moved along the y-axis by hovering over them with the ray and moving the thumbstick along the y-axis.
- **Moving objects towards/away from user**– walls and floors can be moved along the z-axis by hovering over them with the ray and moving the thumbstick along the y-axis.
- **Applying exterior/interior textures** – the texture of exterior and interior walls can be changed by selecting a texture, hovering over the object and pressing the hand trigger on the active controller. Exterior textures will be applied to exterior wall surfaces only and interior textures will be applied to interior wall surfaces.
- **Applying exterior/interior colors** – the colors of exterior and interior walls can be changed by selecting a color, hovering over the object and pressing the hand trigger on the active controller. Exterior colors will be applied to exterior wall surfaces only and interior colors will be applied to interior wall surfaces.
- **Snapping** – objects will automatically snap to the closest right angle on being unselected to make it easier to align with the other objects in the scene.

The table below gives a summary of object interactions:

Interaction	Action on active controller	Applicable objects
Hover	Point the controller ray towards object	All
Grabbing	Hover + Index Trigger	All
Duplication	Grab object+ A/X button	All
Deletion	Grab object + B/Y button	All
Rotation	Hover + Thumbstick x-axis	All
Move object up/down	Hover + Thumbstick y-axis	Roof, Ceiling
Move object away	Hover + Thumbstick y-axis	Walls, Floor
Apply Exterior Color/Texture	Hover + Grab button (Hand trigger)	Exterior wall surfaces
Apply Interior Color/Texture	Hover + Grab button (Hand trigger)	Interior wall surfaces, Floor, Ceiling, Roof

Table1 – Summary of interactions

## 7. Snapshots

Snapshots provide users with a realistic preview of their designs, offering a valuable reference for envisioning how they would appear in real-world applications. The snapshots get saved to the persistent data path using 'Application.persistentDataPath', which provides a platform-independent storage location:

- **On Windows/Mac (Editor or Build):** Snapshots are saved to a local directory on the user's machine, typically under the system's user data folder.

*Example path:*

*C:/Users/<username>/AppData/LocalLow/CS5097\_FP7\_Group03/CS5097\_FP7\_Group03\Snapshots\*

Files are named using a timestamp format:

*Snapshot\_HomeConstruction\_yyyy-MM-dd\_HH-mm-ss.png.*

This ensures each file has a unique name, making snapshots easy to organize and trace.

- **On Meta Quest (Standalone):** Snapshots are saved directly to the Quest's internal storage in the persistent data directory, accessible through file management apps or by connecting the headset to a computer.



*Image 4 – Snapshot of a fully constructed house*

## 5. User Feedback

We conducted a thorough user evaluation of our previous release. Users provided valuable feedback highlighting specific challenges and areas for improvement. Below is the feedback received, along with an explanation of how it was used to finalize the app.

Issue Identified	User Feedback	Solution Implemented in Final Release
<b>Instruction Scene</b>	Users found the instruction scene overloaded with information, glitchy, and hard to read. Instructions were difficult to remember.	Redesigned the instruction scene with a clearer, easy-to-read UI. Added an "Instructions" button on the hand menu for on-demand access.
<b>Object Manipulation</b>	Objects were difficult to handle and challenging to move to the desired location.	Introduced thumbstick controls to allow users to move objects closer or farther with precision.



<b>Object Spawn Location</b>	Objects spawned far from the user, requiring them to move around unnecessarily to retrieve them.	Adjusted object spawning mechanics to place objects within the user's immediate vicinity.
<b>Menu Size and Usability</b>	The menu was too small and inconvenient to navigate.	Implemented a larger, scrollable UI menu for improved usability and better navigation.

Table 2 – Feedback and Implementation

### Key Improvements in the Final Release

- **Instruction Scene:** Redesigned for clarity with better UI and real-time access to instructions, ensuring users have support when needed.
- **Object Manipulation:** Enhanced controls for precise object placement to reduce frustration and improve the user experience.
- **Object Spawn Location:** Updated spawn logic for proximity, minimizing unnecessary user movement.
- **Menu Usability:** Revamped menu design for greater accessibility and ease of interaction.

### Recommendations

- Monitor user behavior to identify further refinements in usability.
- Evaluate the impact of the new features and gather post-release feedback.
- Ensure consistent design across all interactive elements to maintain user engagement.

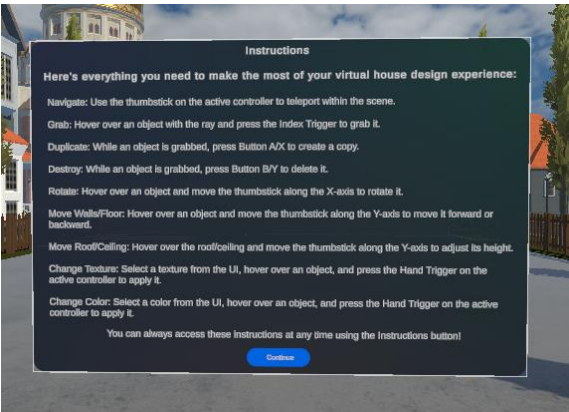


Image 5 – Easy to read Instructions

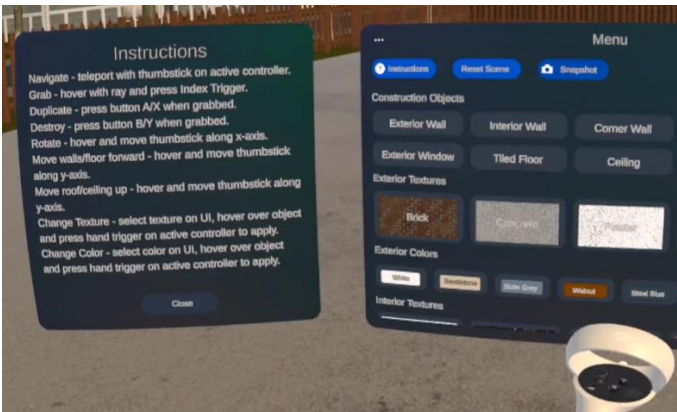


Image 6 – Hand Menu with accessible instructions.

## 6. Reflection

This home construction XR project provided valuable insights into XR development, highlighting the importance of intuitive interaction design, UI/UX refinement, and thorough testing. It taught us the significance of iterative development and balancing functionality with immersion for a seamless user experience.

### What We Learned

- **Designing for Immersion:** XR development requires careful attention to spatial design, realistic interactions, and intuitive user interfaces.

- **Balancing Technical and Creative Elements:** Developing mechanics like object manipulation, snapping features, and UI design highlighted the need to integrate technical accuracy with user-friendly design.
- **Iteration and Prototyping:** Testing ideas in XR environments often reveals unexpected challenges. Iterative development and prototyping are essential for refining both user experience and technical functionality.

### Key Challenges

- **Precision in Interaction:** Implementing mechanics like object placement, resizing, and dynamic spawning required balancing precision and ease of use.
- **Seamless User Navigation:** Designing UI elements that are intuitive in 3D space, such as scrollable menus and handheld instructions, posed unique challenges in accessibility and usability.
- **Hardware Integration:** Working with devices like Meta Quest 2 involved understanding platform-specific constraints and SDKs while ensuring smooth interaction across different input methods.

### Key Lessons

- **Iterative Testing:** User feedback is vital for identifying and addressing pain points.
- **Real-World Testing:** Many issues emerge only in actual XR environments.
- **Simplicity Is Key:** Clear, accessible design improves user experience.
- **Plan for Flexibility:** Anticipating and adapting to unexpected challenges is crucial.
- **User-Centric Design:** Simplicity and clarity are key. Overloaded interfaces or overly complex mechanics can alienate users.
- **Iterative Improvement:** Continuous testing in real-world environments helps identify subtle issues that are otherwise overlooked in simulations.

This project solidified the understanding that XR development is as much about refining user experiences as it is about technological innovation. From designing intuitive interactions to tackling real-world constraints, it has been a holistic learning experience that prepares us for future XR endeavors.