



# SyncCube: An Augmented Reality Room Space Synchronization Tool

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## Introduction

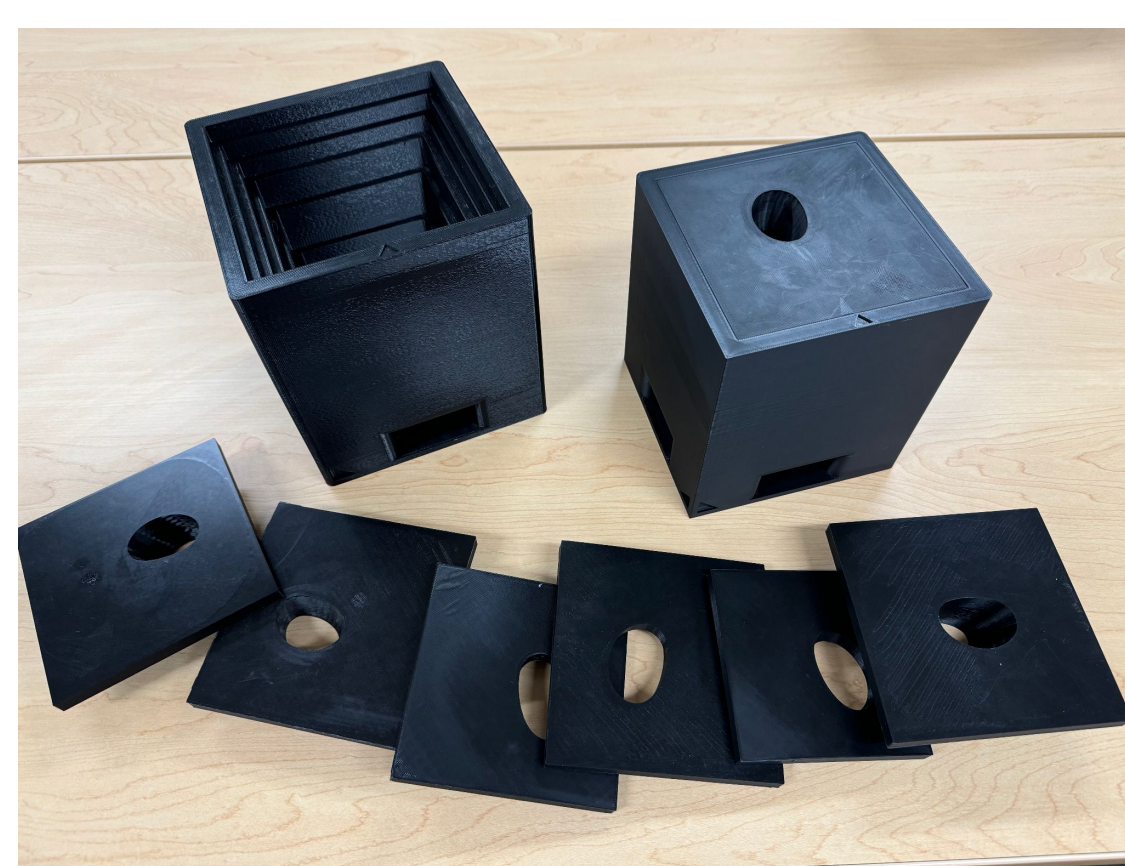
Augmented Reality (AR) allows users to see digital content overlaid on their physical surroundings. One of the most exciting use cases for AR is collaborative work, but this requires a consistent coordinate system between users so that digital content appears at the same locations relative to the room for each user.

Our research addresses this issue through the development of a 3D printed synchronization cube, SyncCube, that allows users to identify the transformation between their own AR headset coordinate systems and a global roomspace coordinate system.

## Design Process

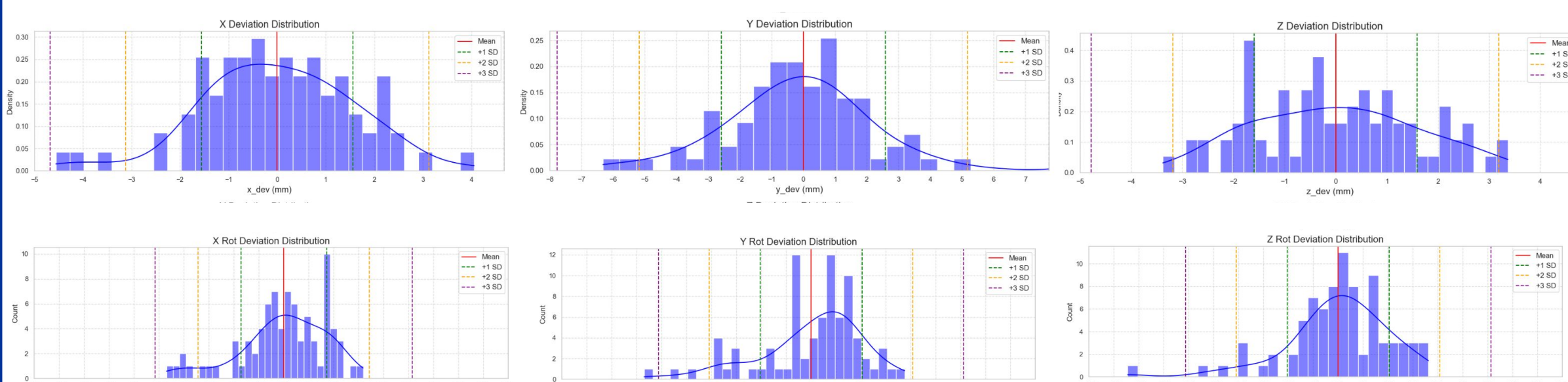
The SyncCube design process focused on three things: (1) Ease of use, (2) Cross-device compatibility, and (3) Precision.

Using CAD software, we iteratively designed a cube with a reversed pyramidal hollow, allowing it to support 3D printed plates of various sizes for different AR devices.

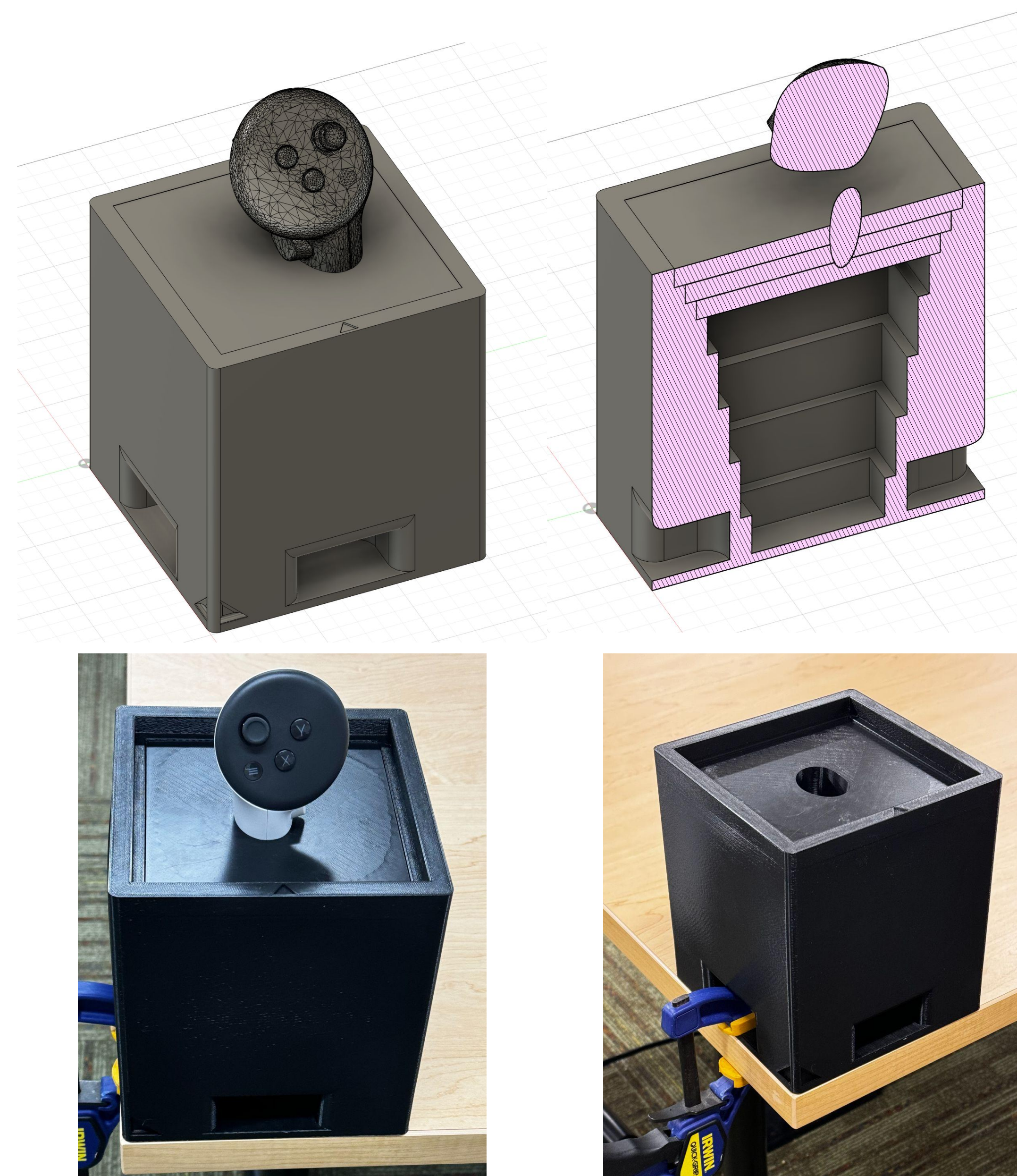


## Evaluation

We tested with the Meta Quest 3 AR display, 3D printing several plates. A 2mm print tolerance provided consistent placement, with about 2mm deviation in all axes and 0.4 in all rotational axes as shown in the variation plots.



## SyncCube



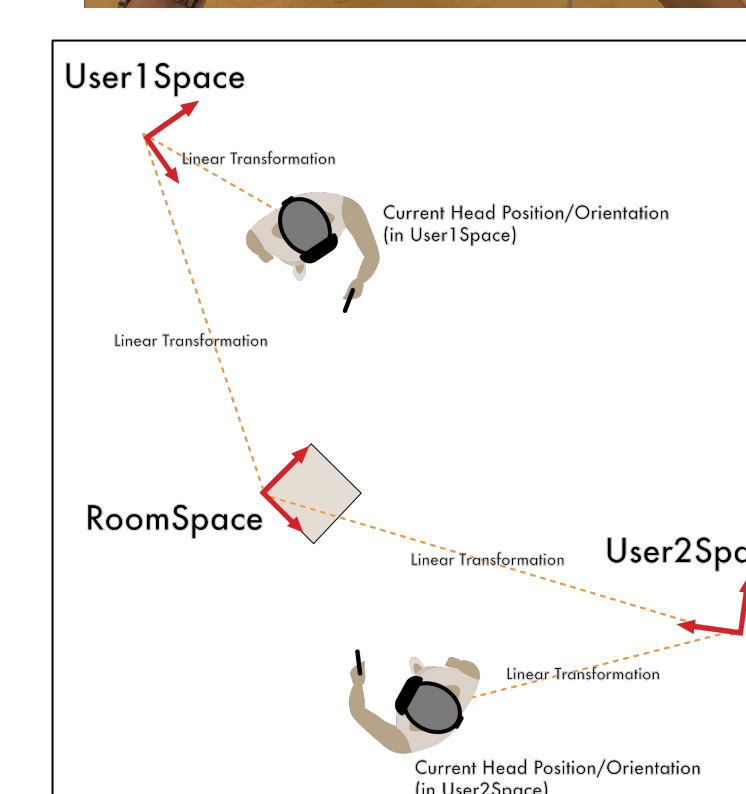
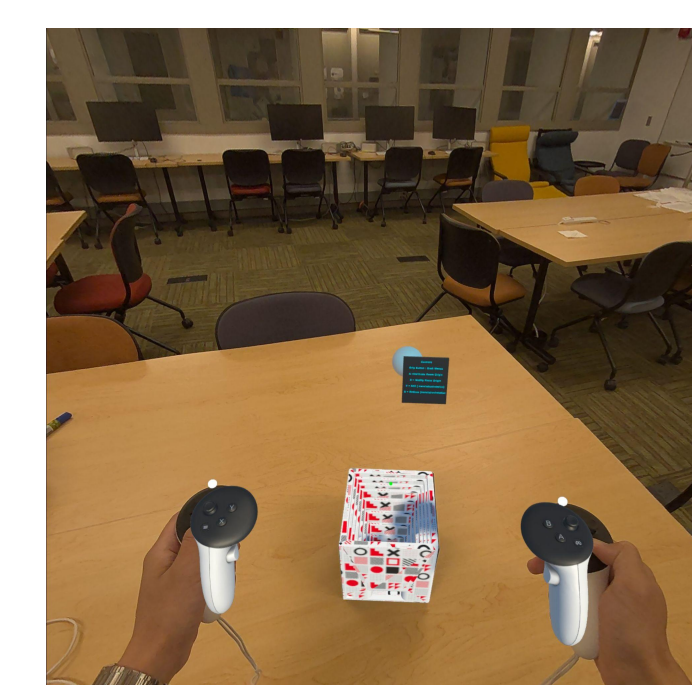
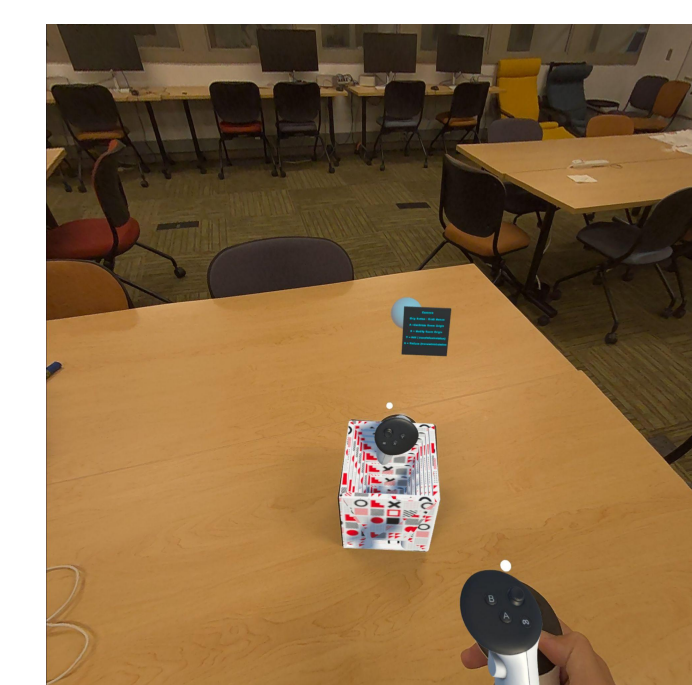
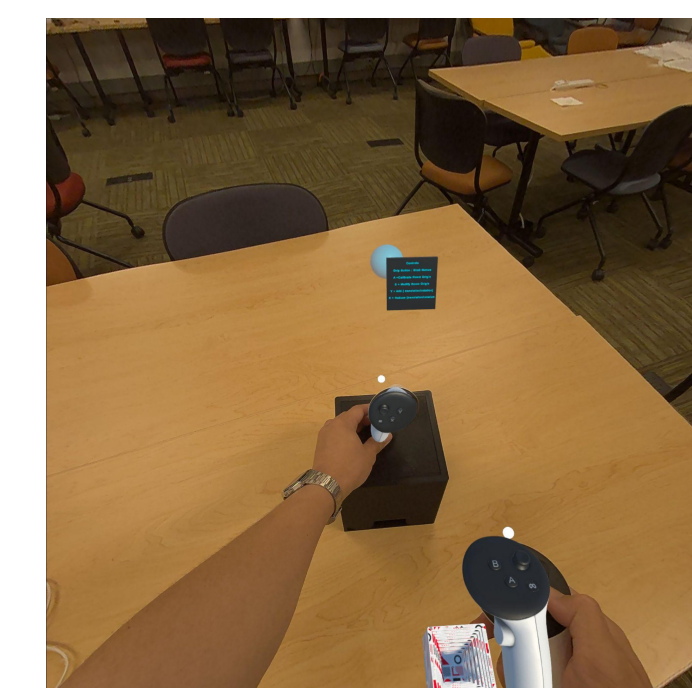
## How it works

1. The user starts the application, and the initial position of the user's head is set as the room origin by default.

2. The user places their left controller on SyncCube. This ensures that the left controller of all users is at the same position, providing a fixed, unified, and stable physical reference point.

3. The user presses the sync button to start the synchronization process. This involves a simple linear transformation that aligns the user's room origin to the left controller's position and orientation.

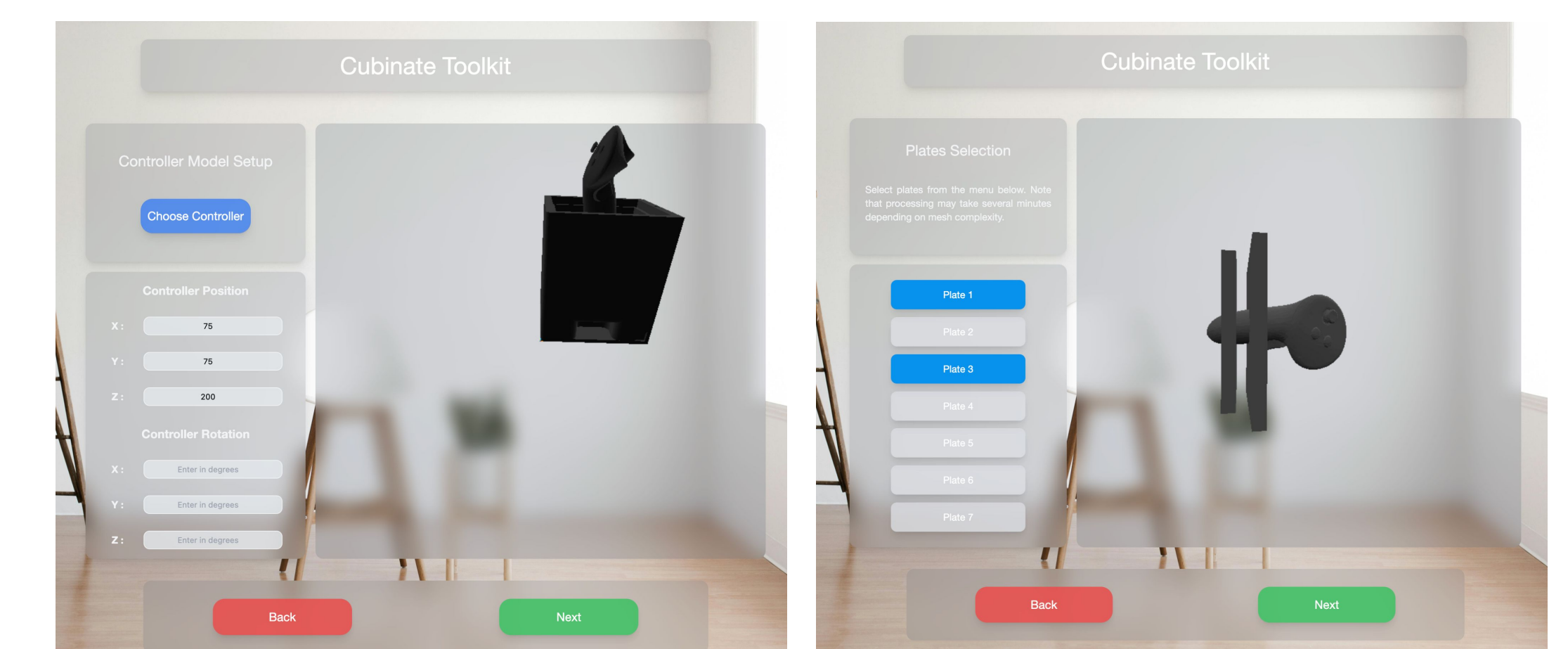
4. After a successful synchronization, all users would have the same origin point.



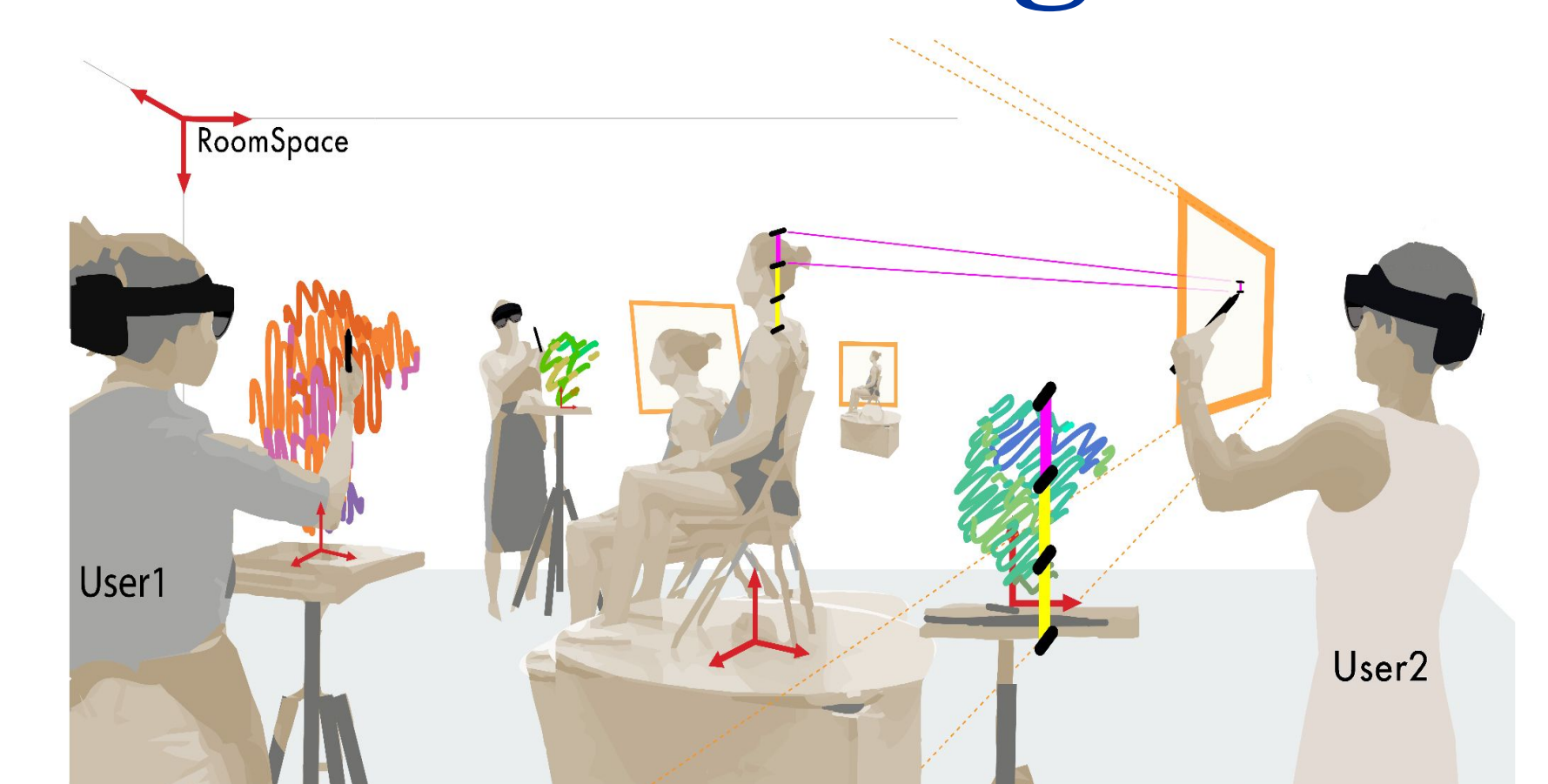
## Web Toolkit

To support easy, cross-device compatibility, we developed a web toolkit to generate plates for new controller types. This tool enables users to upload a new controller model and generate synchronization plates that fit within the SyncCube through a boolean subtraction modeling operation.

Additionally, the web toolkit allows users to adjust the reference point position and select which plates to generate, providing flexibility as needed.



## Future Integration



In the future, we envision using our SyncCube in various scenarios and applications, including:

- **AR Drawing Classroom:** Multiple student users can draw together, see each other, and view each other's drawings in real time.
- **AR Interactive Classroom:** Teachers can interact with different classroom content objects and display them to students, enhancing the learning experience.
- **Collaborative AR Activities:** Students can participate in collaborative classroom experiments and activities in Augmented Reality, fostering hands-on learning and teamwork.