A Transformative Approach for Teaching and Learning Geometry by Representing & Interacting with Three-Dimensional Figures

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Our ClassXRoom
A New Reality in Active Learning

INTRODUCTION

Virtual reality makes it possible to represent three-dimensional concepts as spatially extended, interactable diagrams.

Interactable spatial diagrams can be explored using familiar strategies for navigating space. But unlike other worldly objects, interactable spatial diagrams are free of material or physical constraints. They can be rendered at any size, in any orientation, and at any position in space, and can thereby realize a more varied set of mathematical concepts than what is practicable with physical models.

How might such diagrams create new opportunities for teaching and learning geometry?

GOAL & METHODS

The goal of this study is to investigate whether and how secondary geometry teachers will incorporate interactable spatial diagrams into their teaching. I am investigating two broad questions:

- ***What mathematical topics, content, or concepts do secondary mathematics teachers imagine teaching with interactable spatial diagrams?***
- ***What do secondary mathematics teachers identify as the challenges and opportunities of teaching mathematics with interactable spatial diagrams?***

To answer these questions, I am conducting a design-based study that positions secondary mathematics teachers as participant co-designers. The goals of this study are to collaborate with secondary mathematics teachers to (1) iteratively design a series of immersive virtual environments for exploring mathematical concepts, and (2) develop, test, and refine a set of mathematical lessons that are integrated with those environments.

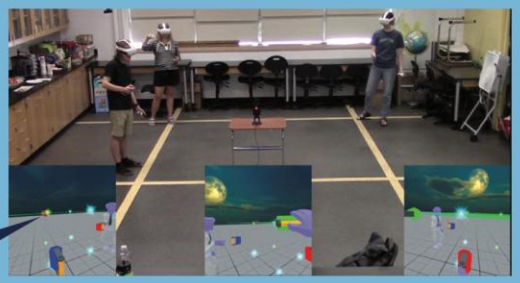
Widget Details

Congruent red, green, and blue disks intersect orthogonally at one point

Diagonal Network Challenge: A Vignette of Doing Mathematics in Immersive Space

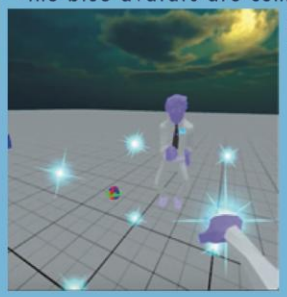
One of the immersive environments teachers explored during the focus group is TriO, a three-player coordination game where each player controls one-coordinate of a widget that is floating in space.

A goal of TriO is for the three players to work together to navigate the widget to a set of electric blue starbursts that are arranged as the vertices of a cube.



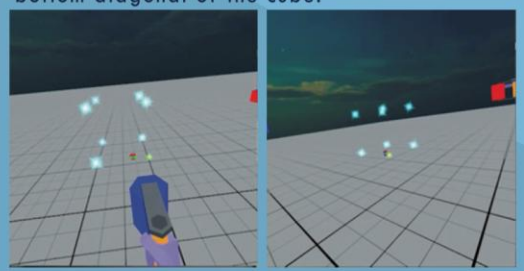
(Above) Mike, Clair, and Kendra (left to right) playing TriO. The embedded views on the bottom are their first-person views of the immersive world. They are wearing Meta Quest 3 virtual reality headsets.

(Below) The widget (red/green/blue) and the starbursts – the blue avatars are controlled by the participants.

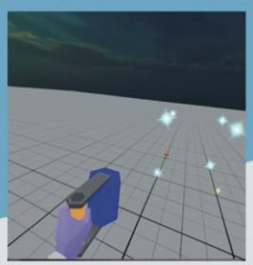


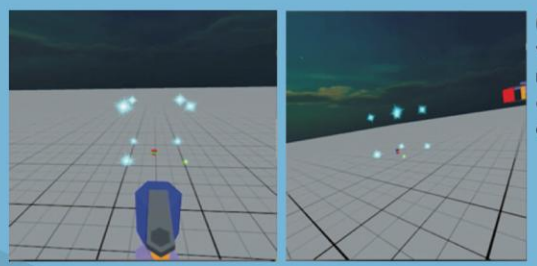
Some paths are only possible by coordinated movement; for example:

(Below) Mike and Kendra coordinate their movements of the blue (Mike/left) and red (Kendra/right) handle to move the widget along a bottom diagonal of the cube.



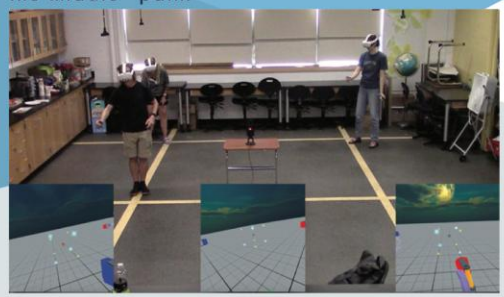
(Right) The widget at the end of the first move, now coincident with the lower, back, left vertex (from Mike's perspective).





(Left) The widget at its midway point along the diagonal.

Other paths were only possible if all three players worked together, such as the "diagonal through the middle" path:



Interested?

The scope of this project seeks to create many more environments, with many different topics.

If you are interested in participating in future deployments in your class, or wish to see a potential vision come true, please email:
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During August, 2024, 6 teachers from schools in rural Maine participated in a three-day focus group, during which they explored virtual environments and sketched ideas for tasks students could investigate in those environments.

During the 2024 - 2025 academic year, 3 of the teachers invited the research team into their schools to test the virtual environments with their students. All of these sessions were video and audio recorded, including first-person views of each participant's experience in the virtual environment.

When the group completed this tri-part coordinated movement, Clair exclaimed "ahhhhhh", as if to mark a shared moment of triumph. The three teachers coordinated their movements without verbal pre-planning and appeared to have a shared sense that they could move the widget along the intended diagonal path by moving each of the three components at the same rate.

CONCLUSION

We are working to analyze the data from the teacher focus groups and from our visits to schools. A challenge for bringing these experiences into classrooms is the time that it takes to get students situated and oriented to the virtual worlds. We found that even 75-minute blocks would fly by while we were working with teachers and students in the immersive environments.

Our plans for this summer and next year are to continue to analyze the data we have gathered already and to conduct a second set of focus groups with teachers. During the 2025 – 2026 academic year, we hope to continue to gather data with students in schools.

Our ClassXRoom's mission:
To explore new possibilities VR can offer education.
To seek out new heights of active learning's success.
To boldly go where no classroom has gone before.