# Assessing augmented reality in helping undergraduate students to integrate 2D and 3D representations of stereochemistry.

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## Introduction

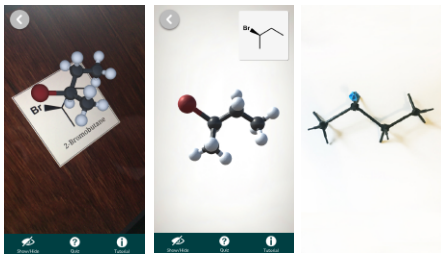
Organic chemistry students exhibit great difficulty grasping stereochemistry and chemical bond hybridization concepts. The 2D representations of molecules presented to them in lectures and exams serve as tools for communication between professional chemists. However, these students' ability to link the molecular formulas, 2D pictures, geometric structures, and molecular characteristics has repeatedly been found challenging. 2D depictions, physical model sets, and 3D computer models are currently used in classrooms and courses in an attempt to tackle the problem of tying the 2D representations to the 3D stereochemistry properties but each tool falls short in one aspect or another. In the present study, we examine how an augmented reality (AR) mobile app combining 2D and 3D representations may be used to support understanding of these concepts.

The research questions guiding this study are:

1. How does understanding of stereochemistry concepts by students using an AR compare to students using physical models and computer generated 3D models on mobile devices?
2. How do students benefit from using a mobile app that integrates 3D models and one that integrates 3D models and AR models?

## Materials & Methods

To answer this question, students from a 2nd-year organic chemistry course at the University of Toronto, Mississauga were assigned to one of three groups: an AR mobile app group (AR), computer generated 3D model app group (3D), and physical hand held model group (MM). Following a baseline knowledge assessment, students completed worksheet activities with their respective group's tool (Figure 1). Following the use of their tool, students completed a knowledge assessment, answering stereochemistry questions.



A B C

Figure 1. Tools used by the three study groups.

A) Screenshot of the AR app
B) Screenshot of the 3D model app
C) Physical hand model of the same molecule

App Development:

Molecular data came from MolView.com, which was then imported into UCSF Chimera, modeled in Maxon Cinema 4D and integrated into the 3D and AR mobile apps using Unity 3D.

## Results

No significant difference in the baseline knowledge between the three treatment groups was found. Students in the AR group (AR) performed significantly better on the post-intervention knowledge assessment than the physical model group (MM). Figure 2 shows a graphical representation of comparative test scores on the post-intervention assessment. No difference was found between the AR app group and 3D model group (3D) in their performance on the knowledge assessment test. Students in the AR group performed significantly better than the molecular model group on question 3 and a notable difference was found in question 1a and 4. A breakdown of the questions is graphically represented in Figure 3.

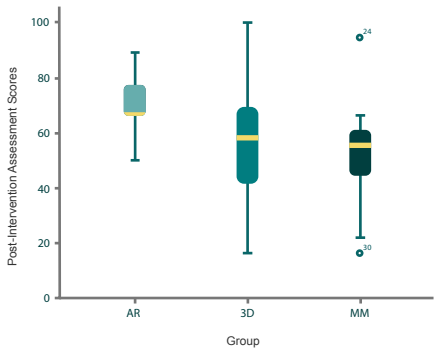



Figure 2. Box Plot depicting comparative scores on post-intervention knowledge assessment.

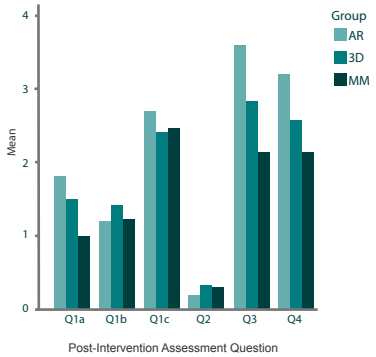



Figure 3. Comparative group scores on individual knowledge assessment questions.

## Discussion & Conclusions

Questions 3 and 4 of the post-intervention assessment dealt with spatial concepts that required students to have higher spatial reasoning skills. With AR group students performing significantly better on question 3 and a notable difference found in question 4, an argument could be made that AR helps students with spatial concepts. However, a follow up study where students are allowed to use the tools for longer periods of time while completing worksheet activities could be helpful. Based on this study, it is possible other disciplines that require students to comprehend challenging spatial concepts could benefit from an AR interface.

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