Teaching Spatial Visualization in Chemistry

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Spatial visualization refers to one's ability to mentally visualize, rotate, and transform objects. It is an important skill that helps with problem solving, with understanding and applying math and science concepts, and with engineering design. While the necessity for spatial skills is known, it is still not clear how to best infuse spatial thinking into primary education.

Applying spatial skills to the study of chemical molecular geometries makes it possible to identify and visualize molecular shapes to determine their chemical properties. The goal of this research was to determine if spatial recognition software on a smartphone could help high school chemistry students develop stronger spatial skills when applied to chemical molecular geometry. The software used was a free phone app, Aurasma. This app recognizes a designated picture, called a trigger image, and displays a 3D augmented reality model created by the designer. These 3D images can be designed and accessed by any user.

For this research, 3D images of 14 chemical molecular geometries were designed. Students in four chemistry classes at Southern High School (a pseudonym) were given access to traditional ball and stick models to learn the structures of the 14 molecules. The students had to identify the molecular geometries of these various chemical compounds. Then, two classes, one regular and one advanced, were given access to trigger images and the Aurasma app to visualize the 3D structures. The students using the app checked their guess of the molecular geometry and used the app to review the material.

All the students were given pre- and post- tests of their ability to identify the molecular geometries of chemical compounds. These evaluations were quantitatively analysed to understand if the students with the added technology had an increase in their 3D chemical geometry skills over the group that just used traditional ball-and-stick models. Surveys were administered to determine whether participants used the app to review the material at home, and if they felt that the app helped them learn the material better than traditional physical models.

The advanced class that used the app had a statistically significant increase in their test scores ($p = 0.01$) and they reported in their surveys that they believed the app helped them advance their understanding of molecular geometry. The regular class had an increase in their test scores as well ($p=0.12$) but it was not as significant as the advanced chemistry class. Even though the advanced chemistry class had a greater increase in their test scores than the regular class, they did not report using the app more often. The advanced students' willingness to learn and their higher level of fundamental understanding of molecular geometry allowed them to significantly improve their scores through the help of the Aurasma app.

Further research could examine if there is transfer of general spatial thinking skills from the advancement of the students' chemical molecular geometry understanding. While this study gained some understanding about the benefits of utilizing the Aurasma app for molecular geometry, there are still many research opportunities to learn about spatial thinking and chemistry.

Statement of Research Advisor:

Natalie's work is innovative, and has already attracted the attention of other teachers who want to help us investigate its effectiveness in different classrooms. Natalie designed and implemented the 3D images used in the study. Her work is the first of its kind, and we anticipate publishing in both practitioner and research journals, so that science teachers and education researchers can learn about the work and build upon it.

—Christine Schnittka, Education