education in chemistry

Is the pen mightier than the app?

By Fraser Scott | 1 July 2020

Tech helps students think differently in acid—base reactions exercises

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Using an app instead of pen and paper may help students with their problem solving

Acid—base theory guides our understanding of chemical reactivity and reaction pathways. Students begin their understanding of reaction mechanisms with acid—base reactions because they are simple and ubiquitous. They form some of the simplest steps in reaction mechanisms, like proton-transfer, for example.

Researchers at the University of Michigan in the US studied how two groups of first-year undergraduates reason through acid—base reaction mechanisms. One group used an app and the other was given a more traditional pencil-and-paper task. The researchers asked students to think aloud to capture their reasoning.

The research team wanted to see how apps can help students understand reaction mechanisms. Sequential alterations of molecules drawn as line-angle structures, as well as electron movement denoted by the ‘curly arrow’, are the most common ways to present reaction mechanisms. However, this is just one of many representations that could illustrate the underlying model for

reactions. More elaborate computer-generated graphics allow for more nuance, animation and interactivity.

The researchers used an app called Mechanisms. This app was developed recently for studying organic reaction mechanisms, including acid—base reactions. It allows users to dynamically manipulate structures over the course of a reaction mechanism. Users can form bonds by dragging electron pairs from one bond or atom to another, and they receive feedback on the chemical feasibility of their actions in real-time.

Applying mechanistic reasoning

The chemical features that both student groups focused on were similar. Both groups also encountered many of the common problems that students have with mechanistic organic chemistry. For example, structures without explicit hydrogen atoms were more challenging when those atoms were needed for an acid—base reaction, irrespective of whether in app- or paper-form.

However, the groups approached problem solving differently. For the pencil-and-paper task, students often focused on surface features of the molecules. They avoided invoking acid—base theory explicitly, and often considered only one mechanistic pathway to find a solution. In contrast, students often began the app task by attempting multiple mechanistic steps, using the feedback provided to guide their thinking. However, they tried things before considering the chemical feasibility.

This study suggests that students might think differently when using more interactive media, like apps, compared to pencil-and-paper activities. That said, it did not find that apps are a panacea for learning organic chemistry mechanisms. During pencil-and-paper activities, students often draw curly arrows without understanding the underlying chemistry. But there is also a danger that students resort to thoughtless interaction with an app without understanding the process, just to get the correct answer quickly. Teachers still need to employ either method skilfully in their teaching so that students can use them effectively.

Teaching tips

You can download the Mechanisms app from the website or your chosen app store. Access to full functionality requires a subscription fee, but there is a free version with a significant amount of useable content. At the bottom of the page you can also find a range of similar games and tools. To get the most out of the app, consider these points:

- The feedback the app provides means it could be used with minimal teacher input, or as a home-learning activity. However, students might require some initial training to use it

effectively.

- Apps, or other computer-based media, provide an opportunity to model chemical concepts in a dynamic, interactive and perhaps more detailed way. These advantages must be balanced with the potential that they introduce unfamiliar models for representing atoms and molecules to students.
- Neither medium is necessarily better, but providing opportunities to use both apps and paper and pencil could afford some synergistic advantages to students' understanding.

References

M N Petterson, F M Watts, E P Snyder-White, S R Archer, G V Shultz and S A Finkenstaedt-Quinn, *Chem. Educ. Res. Pract.*, 2020, DOI: 10.1039/c9rp00260j