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Communication

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ConfChem Conference on Interactive Visualizations for Chemistry Teaching and Learning: Accessibility for PhET Interactive Simulations—Progress, Challenges, and Potential

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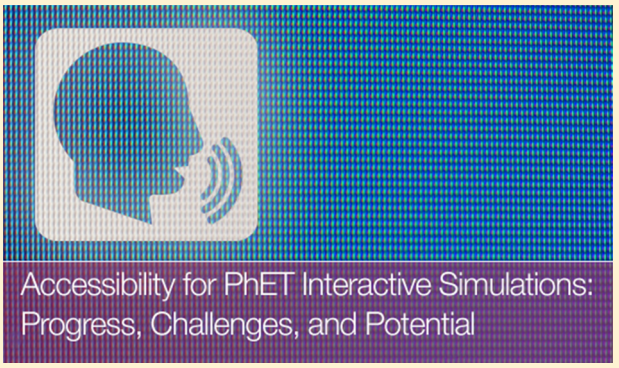
Supporting Information

ABSTRACT: The PhET Interactive Simulations project has engaged in a new initiative to develop inclusive features for the suite of PhET simulations. These features are designed to increase the accessibility of the simulations for students and teachers, with and without disabilities. This communication summarizes one of the invited papers to the *Interactive Visualizations for Chemistry Teaching and Learning* ACS CHED Committee on Computers in Chemical Education online ConfChem held from May 8 to June 4, 2015. The resulting discussion brought up ideas regarding the blending of 3D models with simulations, and the potential benefits and areas of research for sonification within simulations.



KEYWORDS: *Elementary/Middle School Science, High School/Introductory Chemistry, First-Year Undergraduate/General, Curriculum, Computer-Based Learning, Inquiry-Based/Discovery Learning, Internet/Web-Based Learning, Multimedia-Based Learning, Constructivism, Minorities in Chemistry, Professional Development*

The PhET Interactive Simulations project[1] at the University of Colorado Boulder has engaged in the development of free interactive simulations (sims) for learning topics in science and mathematics for more than a decade. The result is a suite of over 130 interactive sims—including over 30 sims on chemistry topics—with supporting teacher materials.[2] Since its inception, the PhET project has prioritized free and easy access to the sims for teachers and students, as well as intuitive, exploratory, easy-to-use sim designs. These efforts have included development of the PhET Translation Utility,[3] which allows volunteers to translate the PhET Web site and sims into their local language or dialect, and the development of sims in HTML5, a markup language that allows the sims to be run seamlessly in-browser and offline on a wide variety of devices—including tablets.

Starting in 2014, PhET has engaged in a new initiative to increase the accessibility of PhET sims for students with disabilities. Partnering with the Inclusive Design Research Centre[4] at OCAD University in Ontario, Canada, we are developing new accessibility features for PhET sims. The new features are intended to support a broad diversity of human needs and preferences, adding customizable affordances for all users. Because the goal of this initiative is to enable the inclusion of students and teachers with and without disabilities, we refer to these new features as *inclusive features*.

INCLUSIVE FEATURES

Inclusive features for PhET sims will be implemented as new interactive "layers". Students and teachers will have the ability to turn layers on or off based on their needs and preferences. The inclusive features include the following:

- **Assistive Technology Support:** The ability to explore, control, and receive feedback from the sim's interactive elements for students using an assistive technology or alternative input device.
- **Keyboard Navigation:** The ability to easily and efficiently navigate and interact with the sim and its representations using keyboard input. This feature will be particularly useful for students with mobility impairments who cannot use a mouse or touch-screen device, and students with vision impairments that use screen readers controlled by the keyboard.
- **Text-to-Speech:** Reading aloud of on-screen text within the sim. This feature will provide auditory access and reinforcement for any text displayed within the sims, useful for students with vision impairments or print-based learning disabilities.
- **Auditory Descriptions:** Reading aloud of contextual information (e.g., describing the scene and layout),

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interface controls, object descriptions, and feedback descriptions. This feature will provide a text-based layer to the sims that supports nonvisual use, enabling students with vision impairments to fully explore and experiment within the sims using a screen reader.
- **Sonification:** Nonspeech sound representations of interactions and science concepts. Sound representations will support students with vision impairments in relating cause and effect relationships in real-time, while supporting other students by reinforcing underlying concepts through visual and auditory representations.
- **Personalization:** Menus that allow students to personalize the configuration of their sim experience, including the ability to turn on and off inclusive features.

PROGRESS, CHALLENGES, AND POTENTIAL

The PhET project has begun developing prototypes of these inclusive features.[5] We have also begun gathering a pool of user testers, including users with disabilities, and deepening our connections with experts in the field of accessible technology and inclusive design.

These efforts are breaking new ground in the design and development of accessible interactive learning technologies and require addressing substantial challenges, including the following:

- **Technical Challenges:** Interactive sims are not structured like standard Web pages, and existing standards that support communication between Web pages and assistive technology devices do not uniformly apply to sims.
- **Design Challenges:** The inclusive sims require multimodal design to support the layering of inclusive features. For example, keyboard navigation design must support learners with mobility challenges as well as learners who may be blind or have limited vision that may be simultaneously using the auditory description and sonification features.
- **Research Challenges:** Each student has a *unique set of needs and preferences* when using technology, e.g., not all keyboard users can be grouped together for analysis. Research methodologies exist for studying situations where it is the unique experience (not the average) that is of most interest, but these are not commonly used within the science education community.

These challenges are worth overcoming, for legal and ethical reasons. Inclusive learning resources can uniquely support the success of students with disabilities in STEM disciplines, while providing benefits that can be used by all students and teachers. A more complete description of these efforts is found in the ConfChem article *Accessibility for PhET Interactive Simulations: Progress, Challenges, and Promise*, available in Supporting Information.

CONFCHEM DISCUSSION

This paper was discussed May 29 to June 4, during the Spring 2015 ConfChem online conference, Interactive Visualizations for Chemistry Teaching and Learning, hosted by the ACS DivCHED Committee on Computers in Chemical Education.[6] The discussion (included in Supporting Information) focused on the use of novel modalities to support learning, and included the use of 3D printed models and sonification. It was suggested that 3D printed models could come with an associated braille-based narrative. One intriguing idea was to couple 3D printed models with an interactive simulation, possibly through the use of a QR code. This coupling would support the addition of a tactile experience to learning from a simulation, or alternately, could provide an auditory guide for physical manipulatives such as molecular model kits. Potential challenges with the pedagogical use of 3D printed models were also addressed.

It was also brought up that sonification is being used to analyze complex data streams, such as the data being collected from the Large Hadron Collider. The role of sonification as a potentially transformative tool for learning—with more research needed to fully understand its potential—was discussed. Areas ripe for exploration include investigations into what sound qualities can convey STEM-specific relationships well, and what sound qualities can contextualize the information being conveyed.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00772.

Full text of the original paper and associated discussions from the ConfChem Conference (PDF)

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Notes

The authors declare no competing financial interest.

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