Supporting Simulation Use for Students with Intellectual and Developmental Disabilities

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GT Sonification Lab

PhET® INTERACTIVE SIMULATIONS

Outline

- PhET Simulations (sims)
- Goals
- Audio-enhanced PhET Simulations
- Research Study Details
- Discussion & Conclusions

PhET Interactive Simulations

- Started in 2002
- 170 Science & Math Simulations
- Run 100+ Million times/year
- 87 languages
- Free to use exploratory learning tools
- Available at https://phet.colorado.edu/

More About PhET Sims

- Demo for John Travoltage

- Who uses them?
  - Students from elementary to college
- What features do they have?
  - Flexible interactions
  - Real-time feedback
  - Varying levels of complexity

Inclusive Design for PhET Sims

- PhET is working to make the sims accessible to more students to support
  - Sim access
  - Learning
  - Collaboration

Goals

- Understand the needs of students with I/DD
- Understand the overlap between needs of students with I/DD and other students
- Explore how to enhance the PhET sims for broader access

How Can We Support More Students?

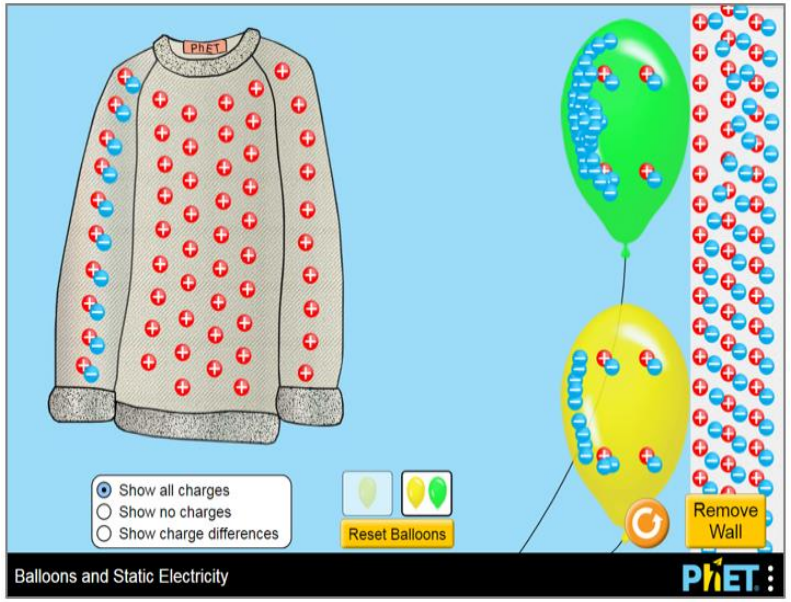
- Audio can provide additional presentation modalities beyond visuals
  - Highlight complex concepts
  - Allow learners to reflect on relationships through audio in addition to visuals
  - Cuing changes and updates in the visuals, especially in the periphery
- Better supports for students with I/DD (Stavroussi et al., 2010)
  - Guided and structured inquiry-based activities
  - Help build knowledge about the world
  - Help them reflect in a meaningful way (metacognition)
- This work explores how auditory displays could support students with I/DD

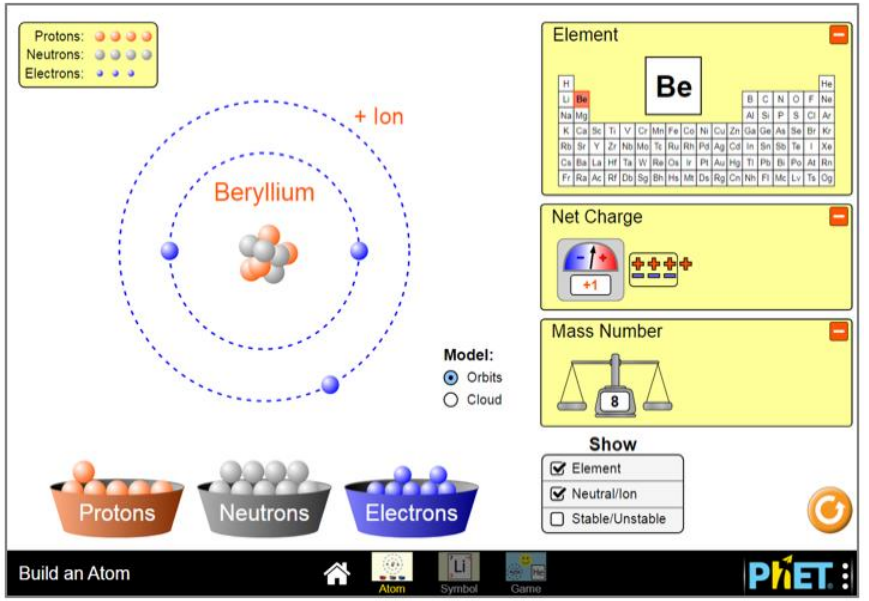
Categories of Sonification

- Non-speech audio
- Auditory Icons (realistic) 
  - E.g., a door shutting
- Earcons (musical, learned) 
  - E.g., victory music from a video game battle
- Mapped sonification (parameters drive audio changes) 
  - E.g., Stock market prices or auditory graphs

Prototype Audio-enhanced PhET Sims

- John Travoltage
- Balloons and Static Electricity
- Build an Atom





John Travoltage – Sound Design

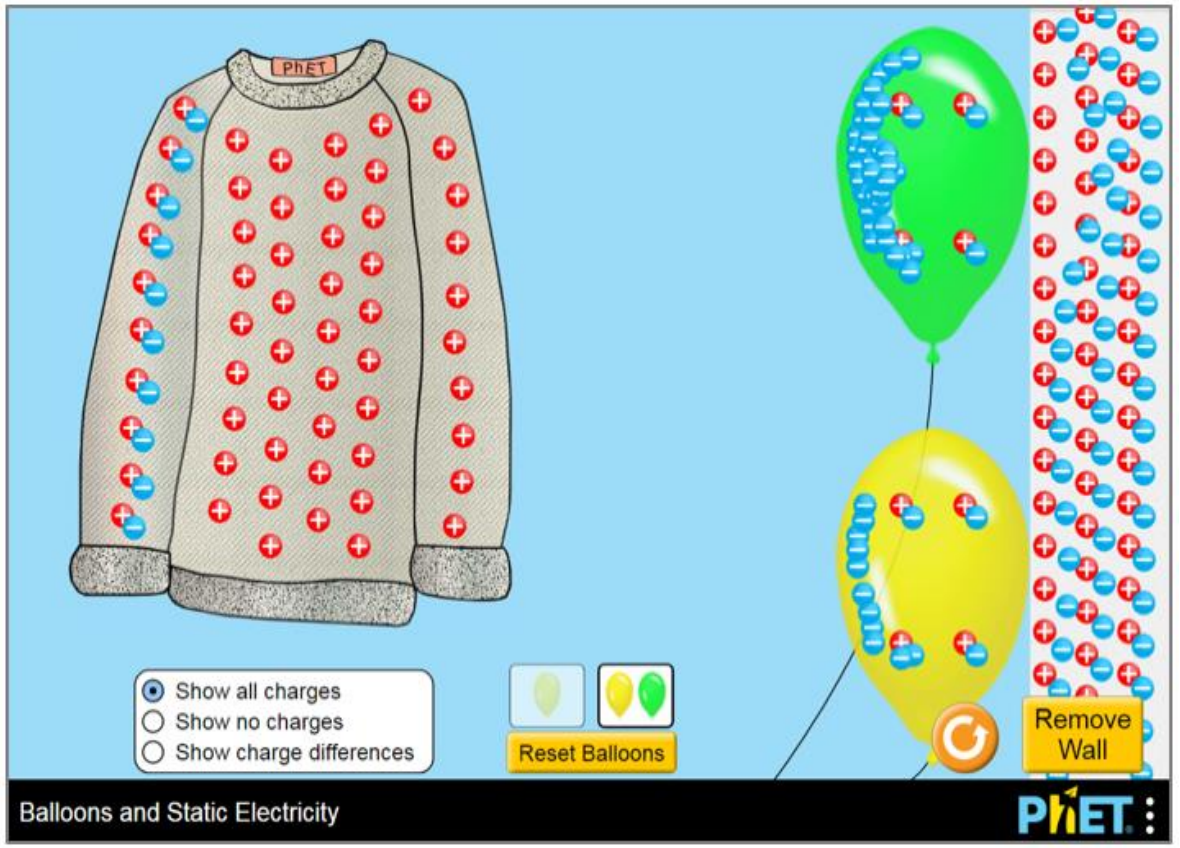
- Auditory icons
  - Foot rubbing on the rug
  - Zap (being shocked)
- Mapped sonifications
  - Arm movement
  - Negative charge additions
  - Movement of accumulated charges

John Travoltage - Demo

- We’ll skip this demo since I did it earlier

Balloons and Static Electricity – Sound Design

- Earcons
  - Pickup and drop for the balloon
  - Other balloon/object interaction (e.g., hitting the wall, rubbing)
- Mapped sonifications
  - Transfer of charge
  - Total charge on balloon
  - Balloon movement when released

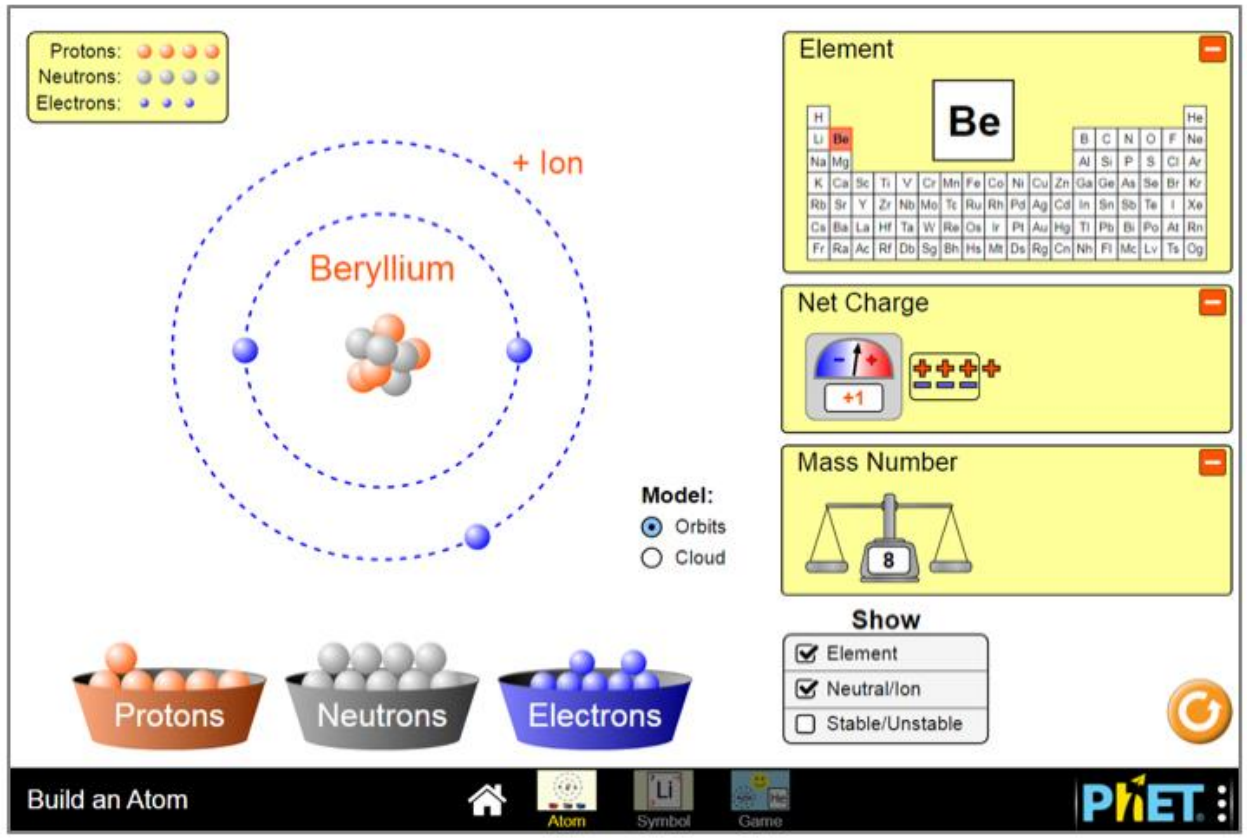


Balloons and Static Electricity - Demo

- BASE Demo

Build an Atom – Sound Design

- Earcons
  - Proton, neutron, electron pickup and drop
  - Unstable representation
  - Positive or negative ion
- Mapped sonification
  - Element type
  - Net charge
  - Mass



Build an Atom - Demo

- BAA Demo

Research Study Details

- Worked with EXCEL Program at Georgia Institute of Technology
  - 4-year residential college program for students with I/DD
  - Academic performance, social fluency, career development, and leadership
  - Independent living & after-college transition
- Students admitted to EXCEL are
  - Diagnosed with an I/DD
  - Have basic math and reading (3rd grade) skills
  - Graduated from an accredited high school
- Summer program
  - 1-week each, 2 total
  - High school students and recent high school graduates

EXCEL Camp Students

- 17 students from the EXCEL camp
- Self-reported technology use
  - All reported daily use and familiarity with smartphones, tablets, and computers
  - 5 reported playing games on consoles or handheld devices
- Self-reported difficulties with school
  - Reading familiar and unfamiliar words
  - Remembering content from lessons
  - Focusing on school and schoolwork

Research Questions

- Can students use the simulations independently?
- What aspects of the visuals and sound support or inhibit student use?
- What use patterns resulted in successful or unsuccessful interactions for students?

Study Design

- Each session was 1 hour total
- Sim 1
  - Free exploration time (5 min)
  - Sim-specific task questions while using the sim
    - E.g., What makes the balloon move toward the sweater quickly?
  - Surveys for user experience and emotional experience
- Sim 2 (if time)
  - Free exploration time (5 min)
  - Sim-specific task questions while using the sim
    - E.g., What particle(s) determine the name of the element you build?
  - Surveys
- Demographics

Sim Use

- John Travoltage only: 4 students
- Balloons and Static Electricity & John Travoltage: 8 students
- Build an Atom: 5 students

Research Question 1

- **Can students use the sims independently?**
  - All students explored the sims on their own
  - Free exploration: some students needed additional encouragement
    - John Travoltage (5)
    - Balloons and Static Electricity (3)
    - Build an Atom (2)
  - Task questions: some students consistently used the sims to answer the questions
    - John Travoltage (7)
    - Balloons and Static Electricity (7)
    - Build an Atom (4)

Research Question 2 & 3

- What aspects of the visuals and sound support or inhibit student use?
- What scenarios resulted in successful or unsuccessful interactions for students?

Common Challenges

- Limited exploration of scenarios
  - E.g., Leaving John's hand close to the doorknob
  - Needed prompting to try different levels of charges
- Unsure how to start initial exploration
  - E.g., Click and dragging of the leg or arm
- Reading and understanding label changes
- Focus on center of the play area
  - Peripheral displays with additional views or interface controls were not used

Audio and Visual Interpretation for Conceptual Understanding

- Understanding accumulation of charges
  - E.g., When John's foot is rubbed on the floor (11 students)
  - E.g., When the balloon is rubbed on the sweater (8 students)
- Understanding relationship between charges and scenario outcomes
  - E.g., Difference between balloon interaction with wall vs. sweater (8 students)
- Understanding changes from one state to the next
  - E.g., Differences between element names (Hydrogen to Helium) and the mass changes (4 students)

Audio Preferences

- Students reported enjoying the sounds in each sim
  - Auditory icons, earcons, and mapped sonifications
- John Travoltage
  - E.g., electron-associated sounds (zap, movement)
- Balloons and Static Electricity
  - E.g., Balloon sounds (pickup and drop, movement)
- Build an Atom
  - E.g., Element representations

Implications

- Students completed lots of productive interaction
  - Well-designed auditory cues can provide a pleasant and meaningful addition
    - Carefully design from literature and aesthetics
- Students clearly referenced the auditory cues in addition to visuals when answering questions
  - Particular prompts for task questions may have supported scenario making
    - E.g., if the wording of the question indicated a contrast: What makes the balloon move faster or slower?

How can we make their experience better?

- Cue other interaction examples directly or in classroom and educational contexts (e.g., effect of charge differences)
- Prompt them to try other comparisons
- Use of scaffolding or instructional support to direct focus to peripheral displays and options
- Use of Text-To-Speech to help with labels and text updates in sim

Resources & Acknowledgements

- Resources
  - bit.ly/csun2018-methods
  - http://phet.colorado.edu
  - http://sonify.psych.gatech.edu
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