Tracing the Development of a Haptically-enhanced Science Simulation for Matter and Intermolecular Force

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Abstract: This poster chronicles the Year 2 work of ASPECT, a 3-year NSF DRK-12 Exploratory Project. The project leverages advanced technology (game engine & haptic controller) to develop and test simulations for the teaching and learning of core upper elementary (grade 3-5) science content including forces and matter & its interactions.

Project Goals

- Integrate Unity & haptics as an innovative teaching tool.
- Design & build a series of prototype haptically-enhanced science simulations for **forces** & **matter and its interactions.**
- Conduct pilot tests to provide *proof-of-concept* & *preliminary estimates* of impact of our simulations.

Our Approach

- *Informant design approach* (children, expert STEM teachers, & content experts).
- Development cycle includes *focus groups* (children & teacher feedback on low-tech versions of simulations & assessments, *usability testing* (task performance, user behaviors, & user preference), & *small scale classroom pilot testing* with grade 3-5 students.
- YR 2 we designed, built, & tested a **Phase Change** & **Intermolecular Forces** haptically-enhanced simulation

Fall Student Focus Group

- Interviewed 12 4th grade students; modified *Children's Beliefs about Matter Interview* protocol (Nakhleh & Samarapungavan, 1999)…see hand-out.
- None of the students exhibited a *macrocontinuous* view (i.e. materials cannot be broken down).
- 75% had *macroparticulate* views (i.e. made of little pieces/parts); 25% *microparticulate* (molecular view of matter)
- The bulk offered *macroprocess* explanations of *why ice melts*…recognized that temperature was part (the entity) but not the mechanism (activity)…"*if water gets cold it freezes*"; "*if ice gets warm it melts*".
- Only 2 two gave any signals of *microprocess* thinking (i.e. a molecular view of the process).
- Recognition of any sort of *molecular forces at work* was non-existent (Erickson & Tiberghien, 1985; Osborne& Cosgrove, 1983; Smith et al., 2006; Wiser & Carey, 1983).

Spring Focus Group

- Involved 9 4th grade students; tested our **core haptic interactions** with objects that modeled *macroscopic physical properties* (viscosity & hardness/compliance) & *microscopic forces* (intermolecular and vibratory).
- **Hardness** was easier to discern; 67% correctly matched the steel, 89% correctly identified the dough & rubber; 75% correctly matched all 3 solid models with their real-world substance.
- **Viscosity** was not as accurate; 33% correctly matched the peanut butter, 44% matched the honey, & 67% recognized the oil; only 33% correctly matched all 3 liquid models with their real-world targets.
- **Phase recognition at the microscal**e…56% correctly matched all three models with its phase; 44% got only the solid correct, confusing liquid & gas.
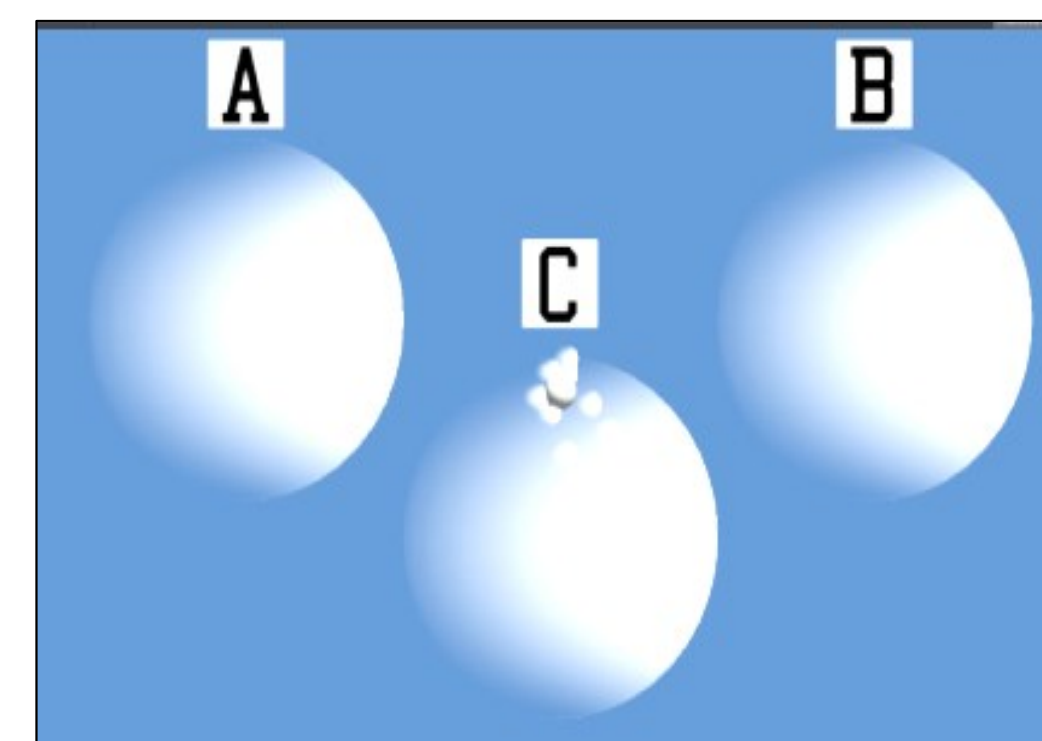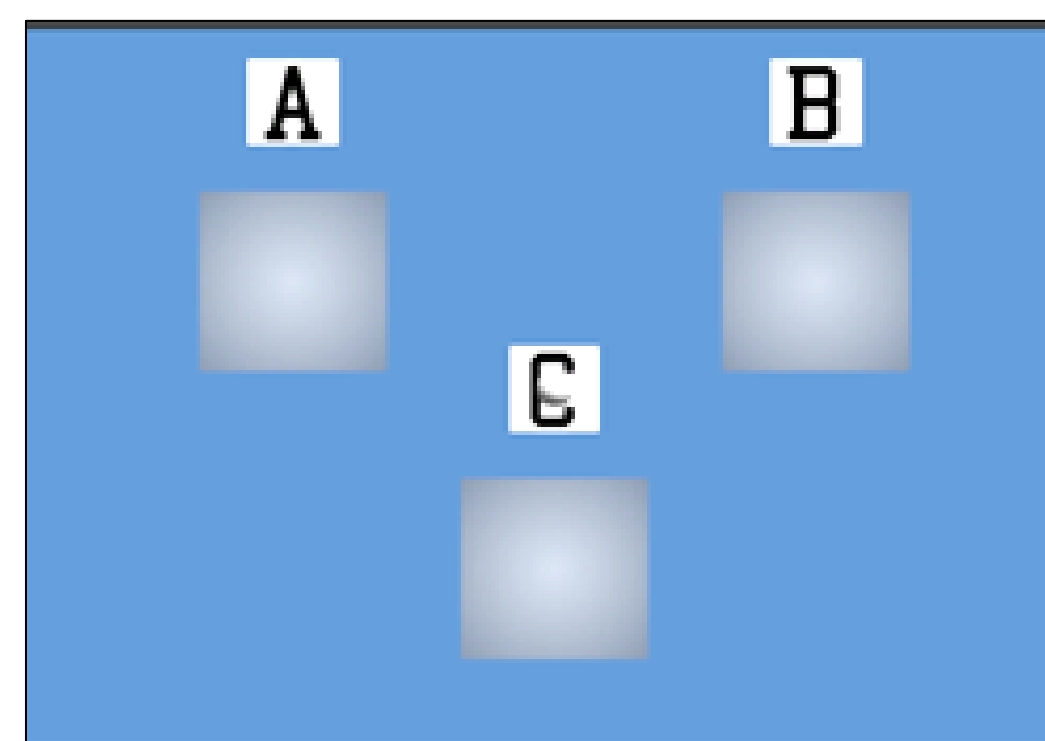
Usability Testing

- 8 4th graders tried out a set of more refined core haptic interactions; modeled hardness & viscosity at the *macroscale* & *microscale*.
- We were interested in users' agility moving between the two scales…feel the models & match the two different levels of representation.
- 62.5% correctly matched all three solid models; 50% matched all three viscosity models.
- In all but one case, if they got all of the solid blocks correct they also got all of the liquid spheres correct.
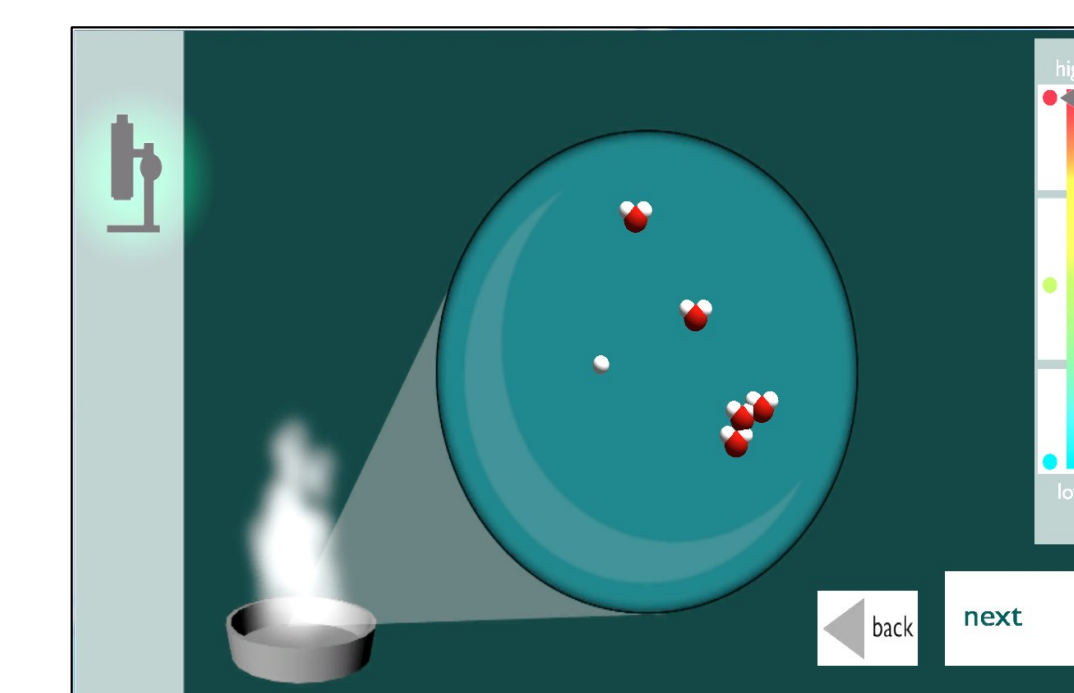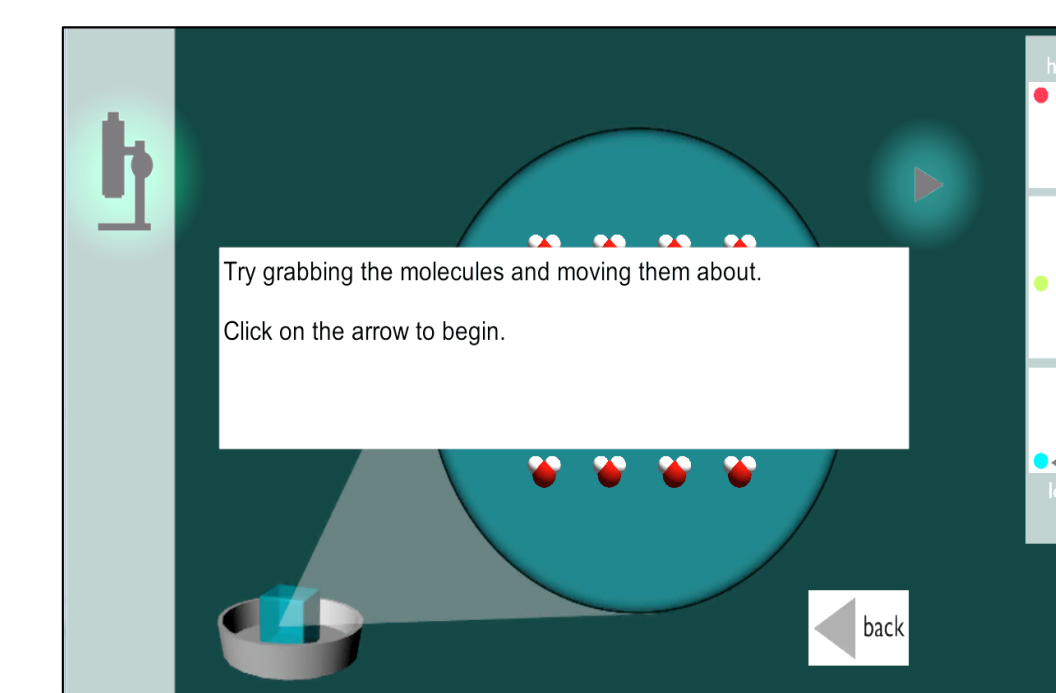- Technical issues (unwanted device vibration & excessive solid surface deformation) emerged.
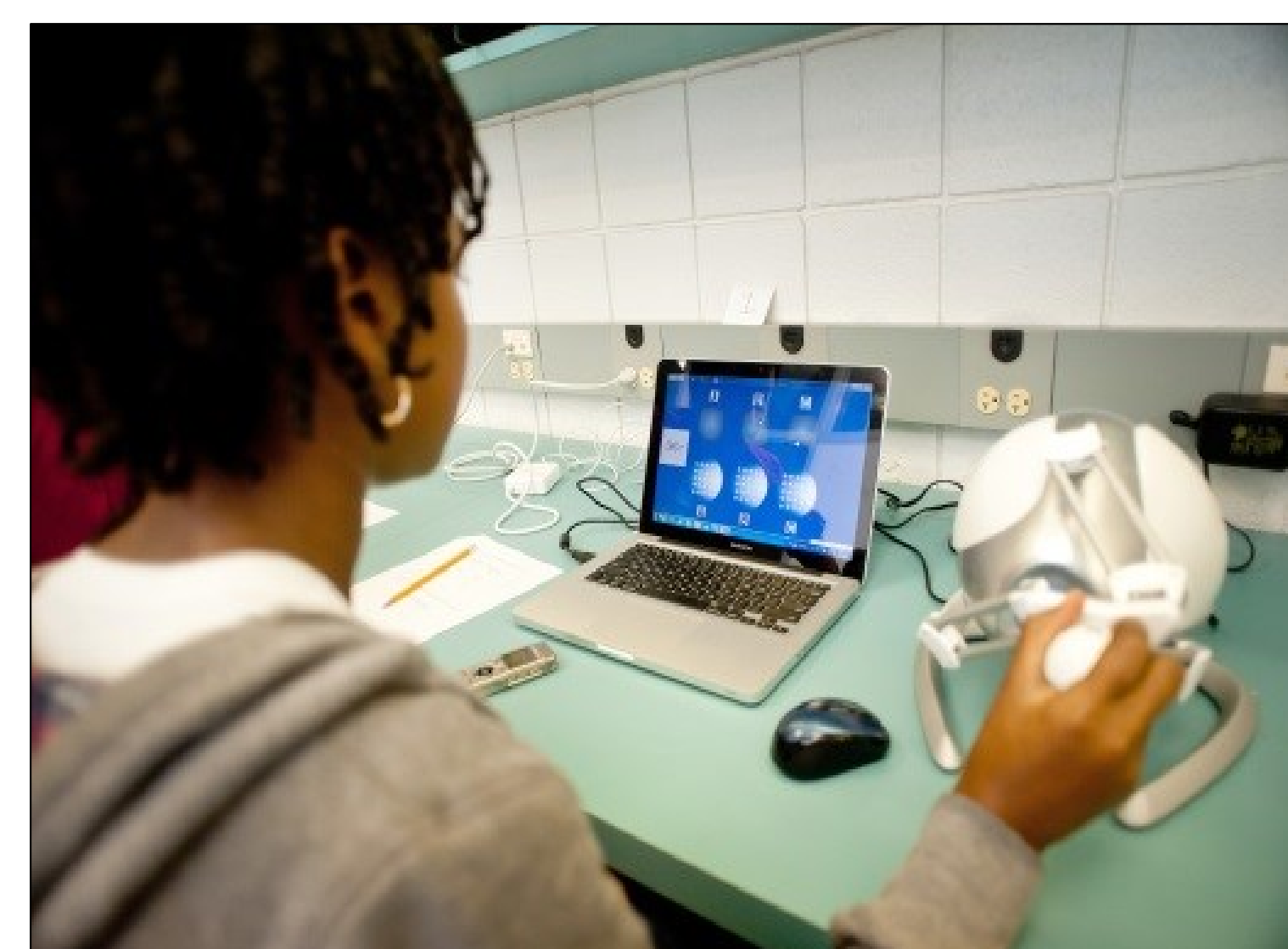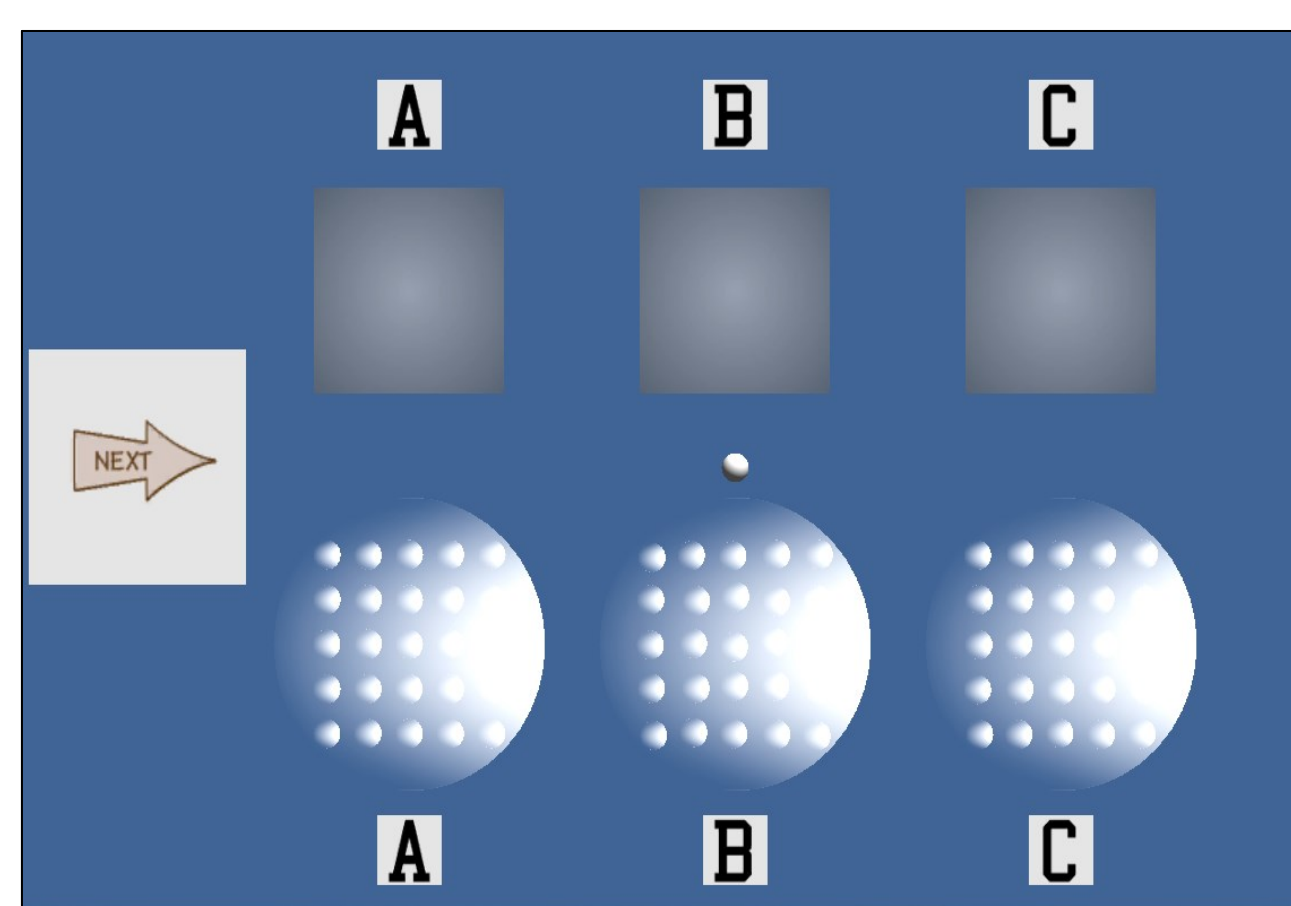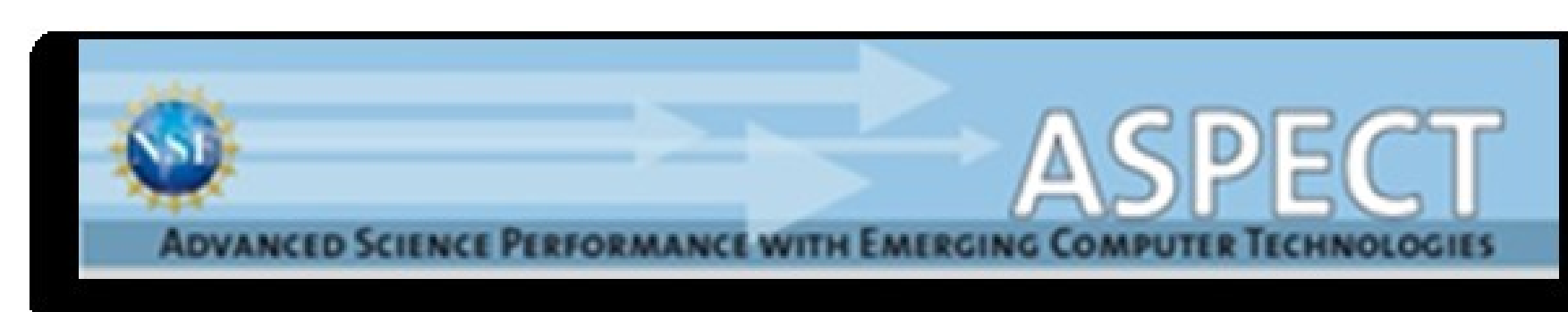
Pilot Testing the Simulation

- Convenience sample (32 5th graders; 18 4th graders)
- Pretest-posttest control group design (haptic vs. no haptic)

Assessments

- Open-ended Drawing & Explanation Tasks… *Ice Melting* & *Physical Properties*
- Interactive Assessment
- Fraps- User Interactions
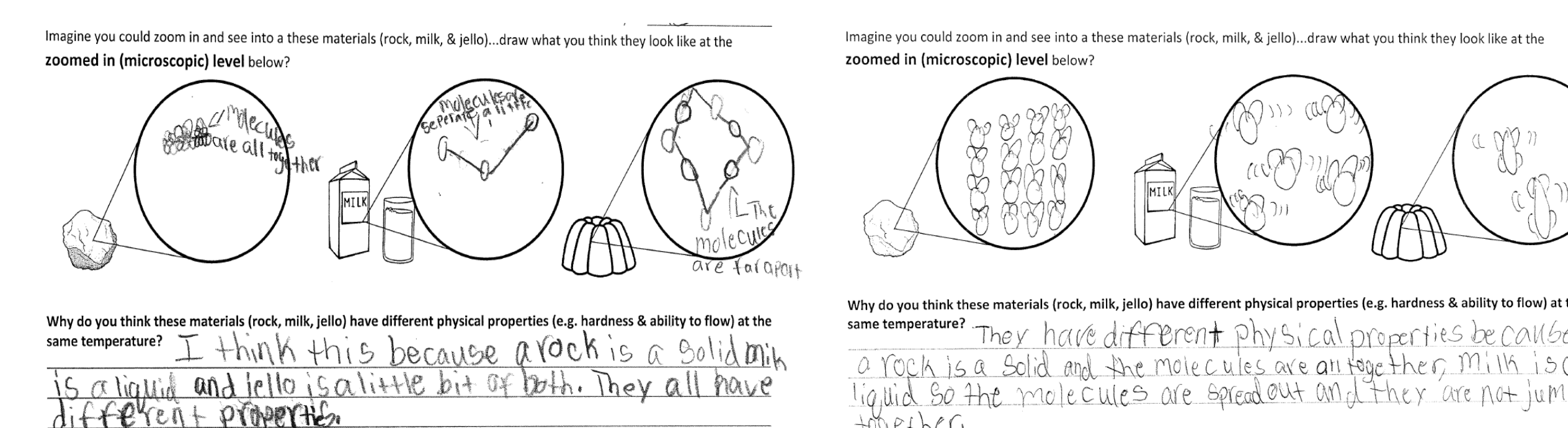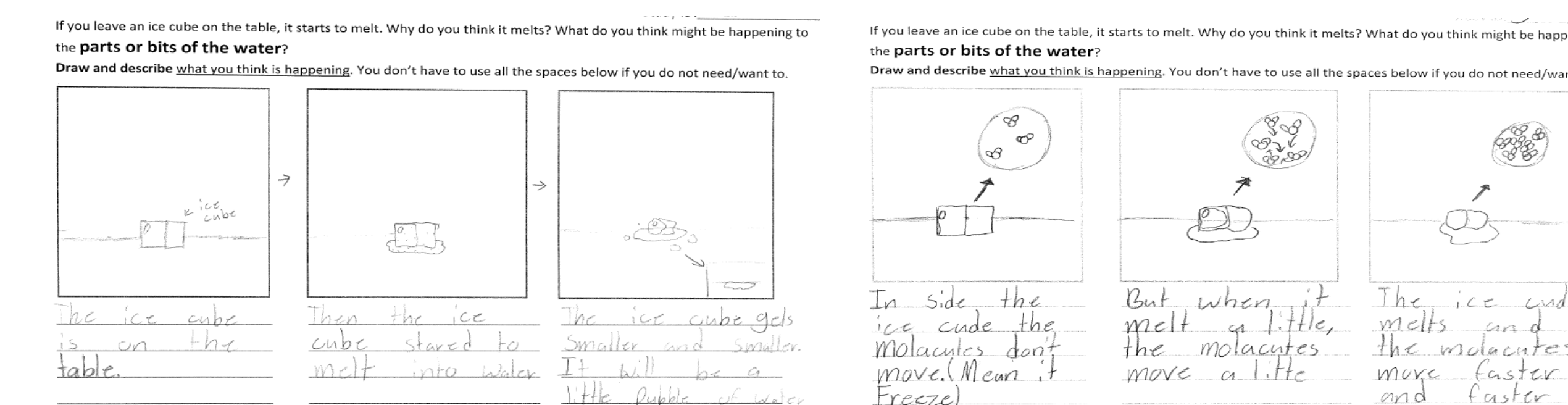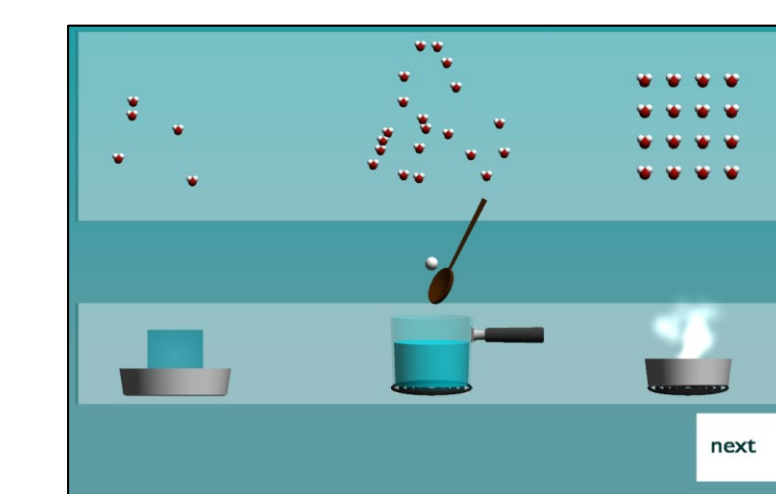
Current Effort

- YR 2 data analysis (see handout w/frameworks)
- Designing & building Y3 Magnetism Simulation

ASPECT
ADVANCED SCIENCE PERFORMANCE WITH EMERGING COMPUTER TECHNOLOGIES