Advancing Science Performance with Emerging Computer Technologies (ASPECT)

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ASPECT ADVANCED SCIENCE PERFORMANCE WITH EMERGING COMPUTER TECHNOLOGIES

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Abstract: **This poster chronicles the Year 1 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.**

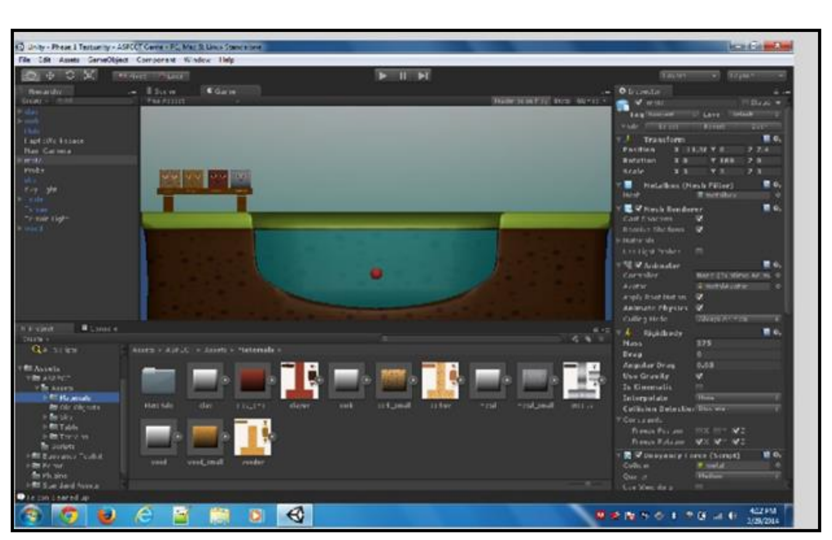
Project Goals

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

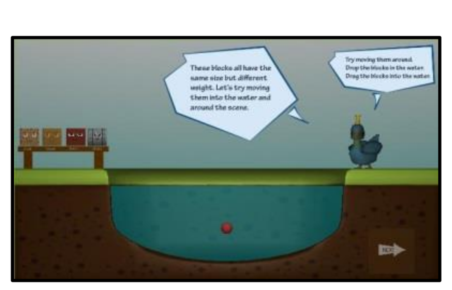
- Clarify the construct of haptically-grounded cognition in an attempt to isolate & describe the differential impact of the haptic augmentation of science simulations.

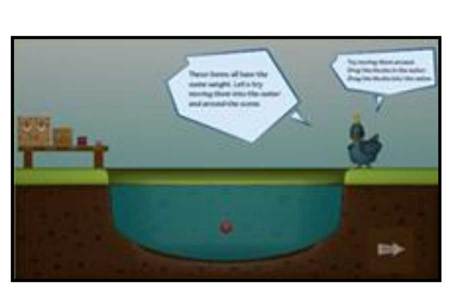
Our Approach

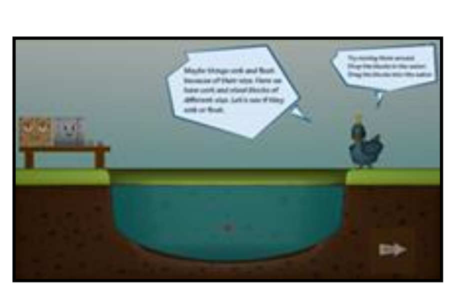
- *Informant design approach* (key informants are children, expert STEM teachers, & content).
- ASPECT's development cycle includes ***focus groups*** (both children & expert STEM teacher informants provide feedback on low-tech versions of our simulations and assessments), ***usability testing*** (generates data regarding task performance, user behavior, and user preference), & ***small scale classroom pilot testing*** with grade 3 and 5 students (N= 48 in YR 1).

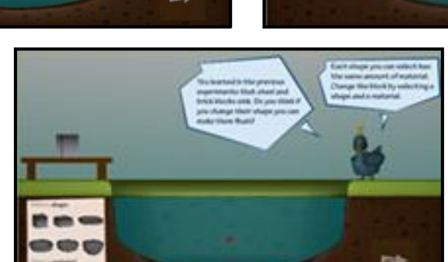


The Simulation





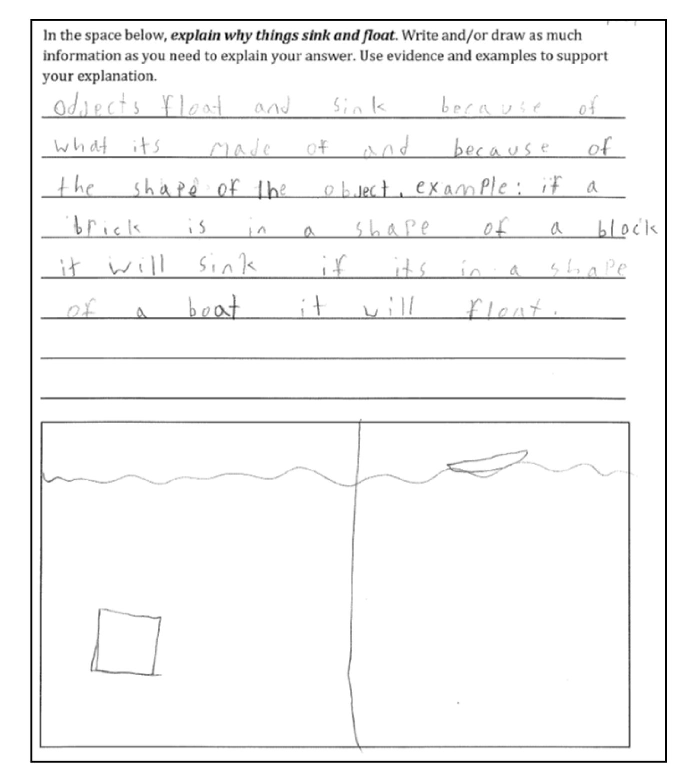




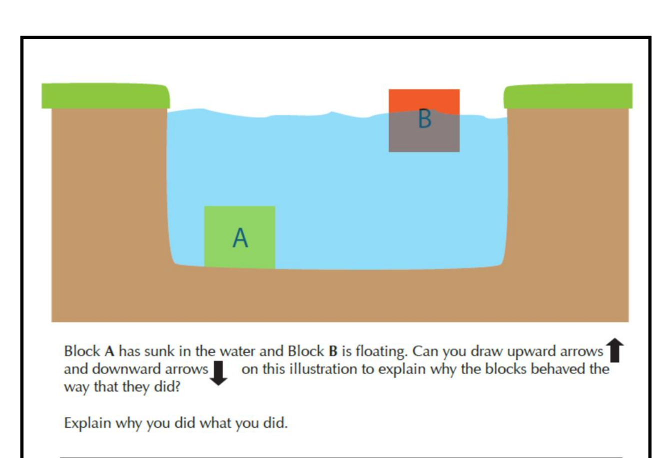
Scene 1: Four objects same size different material.
Scene 2: Four objects different size same weight.
Scene 3: Two materials with two sizes.
Scene 4: Two materials with multiple different shapes.

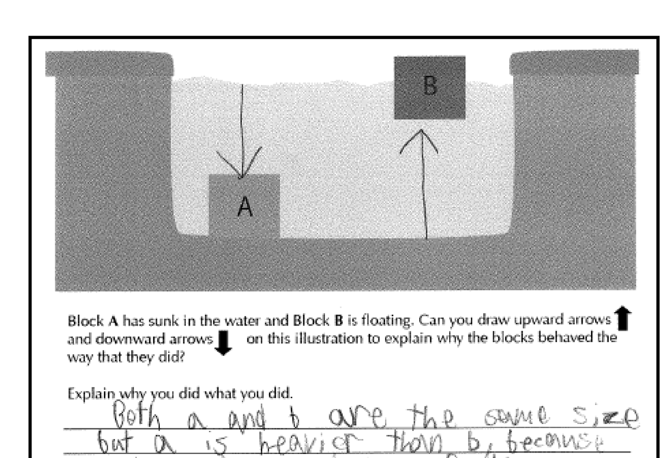
YR1 Accomplishments & Early findings

- Successfully integrated Unity & haptics to create a stable simulation for learning about sinking & floating (buoyancy).
- **Student Focus Group** results showed that students had a lot of difficulty working with the physical materials (e.g. shaping clay), underscoring the *value of virtualizing* these experiences.
- Students seemed stuck (conceptually) at the "heavy things sink & light things float" level. Only a few students considered dimensions other than weight.
- **Pilot-testing** showed that, regardless of their treatment group, third graders gained 0.75 points and fifth graders gained 0.95 points on our SOLO taxonomy (see handout) for the WTSF prompt, suggesting that our simulation did help students reason about the phenomena.
- Third grade students having haptic (force) feedback showed an average of 2.92 on the posttest compared to 2.27 for the visual only group (gains of .846 and .636 respectively). The Cohen's d of 0.35 (modest effect size of haptics for the 3rd graders). No significant differences were observed in the 5th graders from our study.



- Many users moved beyond the incomplete notion that things sink or float because of the weight alone to consider additional factors like the material itself and the shape of the object; early evidence of a move from *phenomenon-based reasoning* to *relation-based reasoning* (Driver et al., 1996)? A *stepping stone* concept? (Wiser et al., 2009).
- Results indicated that on the free-body diagramming task (regardless of treatment) 10% didn't draw any arrows, 81% drew one arrow on each object (downward for the sunken block and upward under the floating block), & (8%) drew multiple arrows surrounding each of the blocks. We have no evidence of students using opposing forces in their drawings or explanations. This finding is in line with earlier work describing conceptual difficulties here (e.g. Driver, Rushworth, & Wood- Robinson, 1994; Heywood & Parker, 2001).





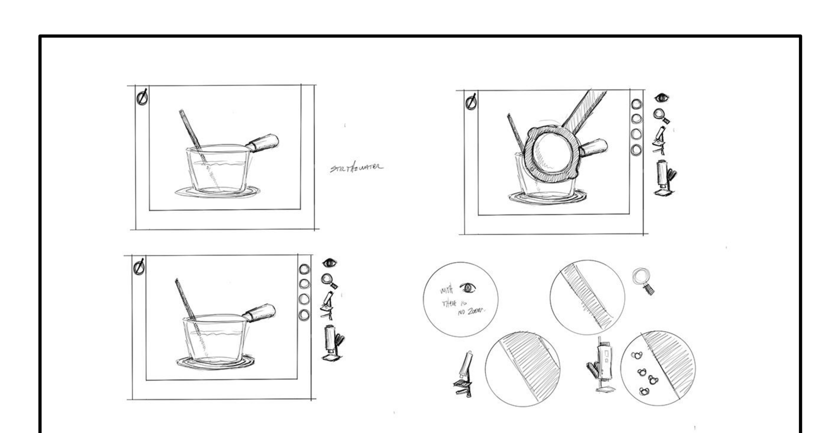
HCI Implications

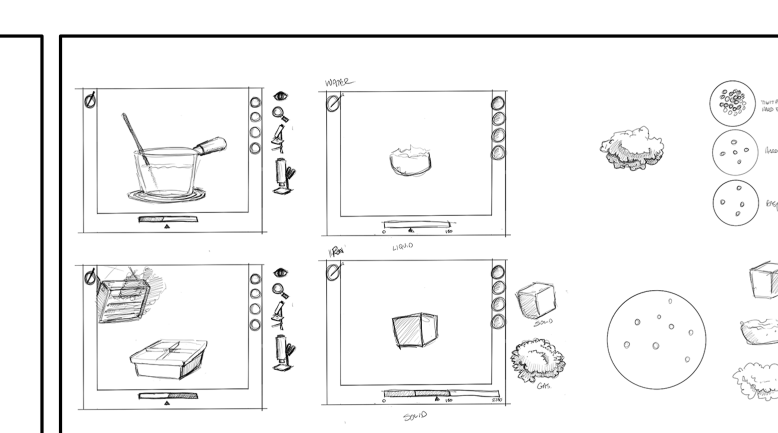
- Users may not be fully capitalizing on the force feedback the haptic device affords them. We found that users in the haptic feedback treatment did not hold the objects in/under the water as we expected them to do intuitively.
- This inaction may have lessened the cognitive impact of being able to "feel the buoyant force" and lends credence to Klatzky, Lederman, and Matula's (1993) visual dominance model of haptic cognition where visual analysis is exhausted before any haptic exploration is initiated.
- User control issues also impacted the students' interactions with the simulation.

Current Efforts

- We have developed a typology (based on Driver et al., reasoning framework , 1996) of user behaviors captured by screen recording software. It looks for signals of attempts to reason about sinking & floating (e.g. considering multiple dimensions of the phenomena & hypothesis testing) (see handout).
- We are also looking for change/progress in students' responses to the in-simulation prompts.

- We also plan to analyze their written WTSF responses for use of haptically-grounded terms (e.g. push, pull, force).
- We are simultaneously designing & developing our YR 2 haptically-enhanced simulation & assessments around physical properties, phase change, and intermolecular forces .





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