Tracing the Development of a Haptically-enabled Science Simulation (HESSs) for Force and Motion

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"To be able to teach effectively, teachers need to be given the opportunity to learn (or relearn) physics in a manner consistent with how they are expected to teach." (McDermott, 2006, p. 759).

Context

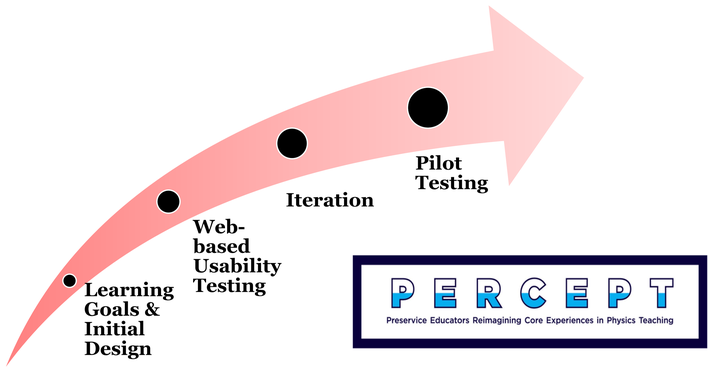
- Our work integrates the Novint Falcon force-feedback device & Unity® game engine to create our **haptically-enabled science simulations** (HESSs)
- Virtual representations modeled computationally & augmented with haptic force-feedback
- Interested in the influence of haptic force feedback on preservice teachers' development of a **functional understanding** of how their students learn about force and motion.

Learn More About Our Haptic Technology Here

Conceptual Stumbling Blocks

- an object in motion has a **force within it** which keeps it going
- **constant motion** requires a **constant force** or else the moving object will gradually stop as the "**force gets used up**"
- **net force** as an "extra" **real** force in addition to the actual forces on an object
- **acceleration** is the **same as velocity** & always in the **same direction**
- if velocity is zero then acceleration must be zero
- acceleration always means that an object is speeding up

Graham, Berry, & Rowlands, 2013; Halloun & Hestenes, 1985; Hast & Howe, 2013; Mulhall & Gunstone, 2012; Rosenblatt & Heckler, 2011; Thijs, 1992; White, 2012



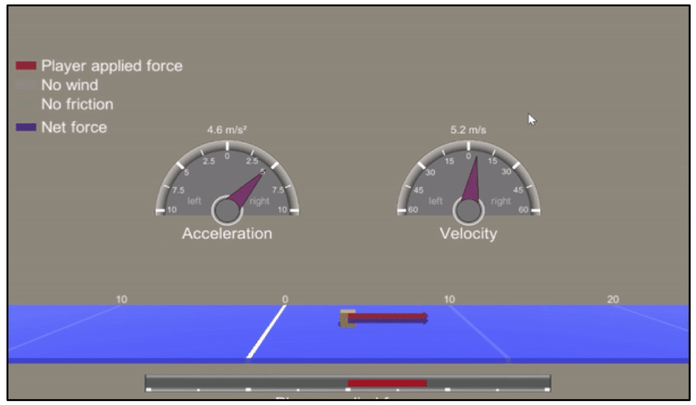
PERCEPT
Preservice Educators Reimagining Core Experiences in Physics Teaching

Functionalities

- users apply a horizontal force to move the object on a frictionless surface; "player applied force" arrow stretches to the left or right
- a force with the indicated magnitude & direction is applied
- the user can turn a wind force on/off to introduce a separate constant force to affect the object's motion
- the motion of the object is computed based on the sum of the forces
- the user can change the size of the box
- the simulation can be paused at any point

Usability Testing

- N= 21 preservice teachers
- An interactive mouse-driven simulation
- Built using Unity 5.6.7 & deployed as a browser-based WebGL project in Qualtrics



More details about the Usability Testing found here: https://go.ncsu.edu/noahnd2

Current SIM

- now haptically-enabled…we integrated a Novint Falcon force-feedback device
- added a friction force
- task-based prompts
- PCK assessments

Try Out the Simulation Here!

Choose the smallest box and turn on the low friction. Move the box to the left. What do you notice?

Reset the simulation. Now try the same thing with a larger box. What do you notice? How does this compare with the smaller box?

Reset the simulation. Choose the smallest box and turn the wind force on. Try to make the box stop moving to the right? Explain what you did below.

Read the following question from a **student assessment** on forces and motion, and then answer questions below.

Student Assessment Item

Maria is asked by her teacher to move a file cabinet. As she pushes, the cabinet begins to move. What will happen if she keeps pushing just as hard as she did when it first started to move?

A. The file cabinet will keep going at the same speed.
B. The file cabinet will speed up until it gets to the speed that matches Maria's push.
C. The file cabinet will go faster and faster.
D. The file cabinet will speed up until Maria's push is used up.

The above multiple-choice question is administered to a group of upper elementary school students. If a **majority** of your students **select answer choice "A"**, **what does that tell you about their understandings** of this concept?

Describe what would you do next in your work with these students?

Taken from: ATLAST from Horizon Research http://www.horizon-research.com/atlast/

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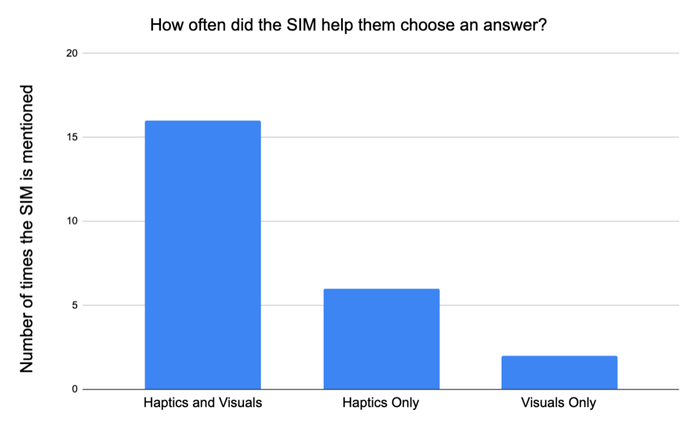
Pilot Testing Underway…Early Data

QUESTION: A box is on a level surface without friction. The box is moving to the right with a constant velocity. Which of the following best describes the scenario? **ANSWER:** There is no net force on the box

Haptics and Visuals		Haptics Only		Visuals Only	
PRE	POST	PRE	POST	PRE	POST
I believe the velocity has to do with the speed and so if a constant velocity is being put on the box there is a constant force pushing the box	When there is not net force the velocity is at a constant speed	If the box is moving to the right at a constant velocity there must be some force causing it to move in that direction.	In order for velocity to be constant there must be no forces acting on the object	Something has to be pushing the box for it to move.	A force has to be moving the object to the right.
0/4 correct	3/4 correct	0/3 correct	1/3 correct	1/3 correct	1/3 correct

QUESTION: A box is on a frictionless surface. The object is moving to the right, and a constant force (ex. wind) to the right is being applied. A force with equal strength pointing to the left is then applied. What will happen to the object? **ANSWER:** It will continue moving to the right

Haptics and Visuals		Haptics Only		Visuals Only	
PRE	POST	PRE	POST	PRE	POST
If two equal forces are applied at the same time, then they would cancel each other out.	I did this in the simulation and the box continued moving to the right.	I think it will slow down and stop because since the forces are of equal strength, then the net force is zero, which would cause it to not be in motion.	These forces will act on each other and cause a net force of zero, canceling out any movement.	It might depend on how long the equal strength force lasts, but if there are two equal forces on an object acting in opposing directions they are going to cancel each other out (and that is what I am assuming is happening here).	The forces cancel each other out
0/4 correct	2/4 correct	0/3 correct	1/3 correct	0/3 correct	1/3 correct



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