Creating Cognitive Conflict In Mechanics Using "Virtual Reality" Simulations

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Cognitive Conflict

- Many instructional reforms in physics focus on confronting misconceptions. This is one way of evoking cognitive conflict – a disconnect between expectations and experience – within our students.
- Once students are in a state of conflict, two instructional approaches are common:
  - provide the students with an alternative explanation; this is most common in monologues like lectures or textbooks
  - provide the students with tools for seeking out or "discovering" an alternative explanation; this is usually more productive, as it actively engages the student

A Virtual Environment

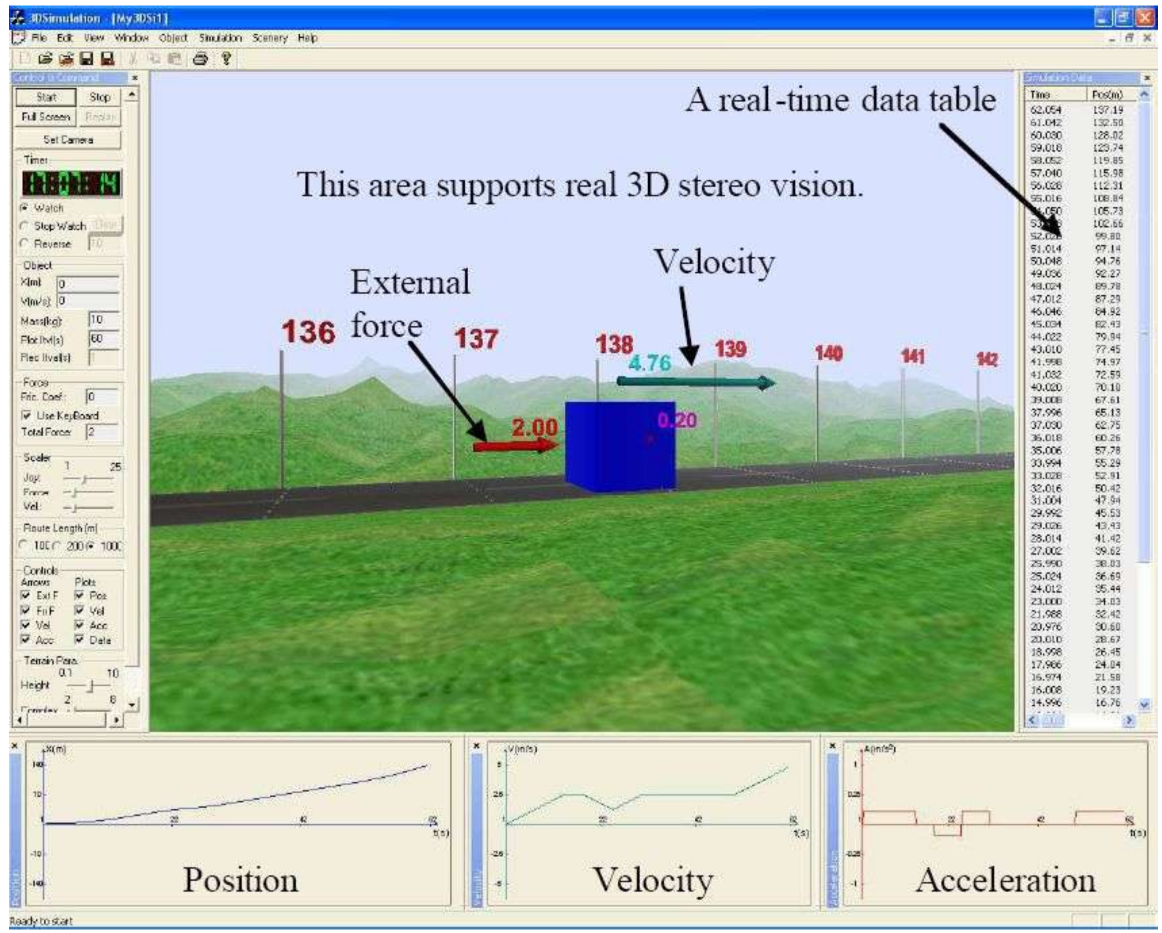
- We are developing a number of physics simulations using 3D graphics.
  - support for stereoscopic 3D viewing
  - movable “camera” in the Virtual Environment (VE)
  - multiple input options, including joystick
  - flow of time can be slowed down, sped up
  - dynamic interaction with simulated objects in real time
  - physical properties of simulated objects are easily changed

Exploring the Virtual Environment

- Our simulations are designed to allow students to explore and discover physical phenomena, rather than serving as demonstrations of externally asserted rules.
  - basic physics is programmed in but students can, for example, apply whatever forces they wish at any time
- As in a lab environment, we ask students a question and they are free to see what works and what doesn't.
  - when they expect something to work, but it doesn't, they will experience cognitive conflict
  - because of the openness of the VE, they will be able to look for answers in an active “doing” mode instead of a passive “watching” mode

Trials: 1-Dimensional Motion

- This module simulates linear motion, with or without friction, with forces applied at will by students using an analog joystick (i.e. “flightstick”).
- Serves as a limitless “air track” apparatus with automatic data-collection, graphing, and vector display.

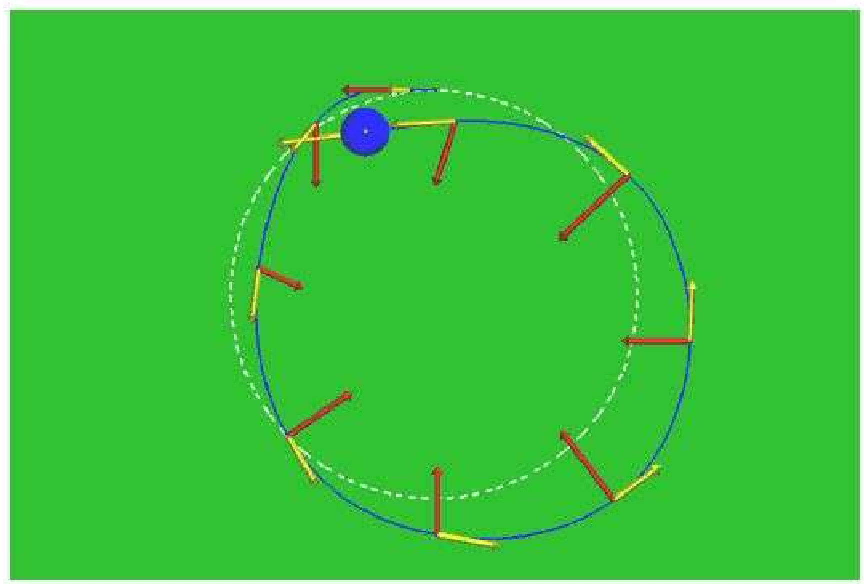


Trials: 1-Dimensional Motion

- Interviews with five algebra-based intro students.
- Questions probed ideas about force and velocity:
  - what happens to an object when a constant force, greater than friction, is applied?
  - how should forces be applied to accelerate an object from rest to some speed, and then maintain that speed?
- During the sessions, each student displayed cognitive conflict regarding their ideas about force and velocity.
- With varying effort, each came to state correct ideas.
  - However, retention on post tests was "normal". A control group who did a non-computerized activity fared the same.

Trials: Circular Motion

- Simulates motion in a horizontal plane. External force (magnitude and direction) is applied with the joystick.
- Students are asked to move the ball along a circle.
- Displays a “trail” showing path and applied forces.
  - upon success, the “central force” idea is clearly seen

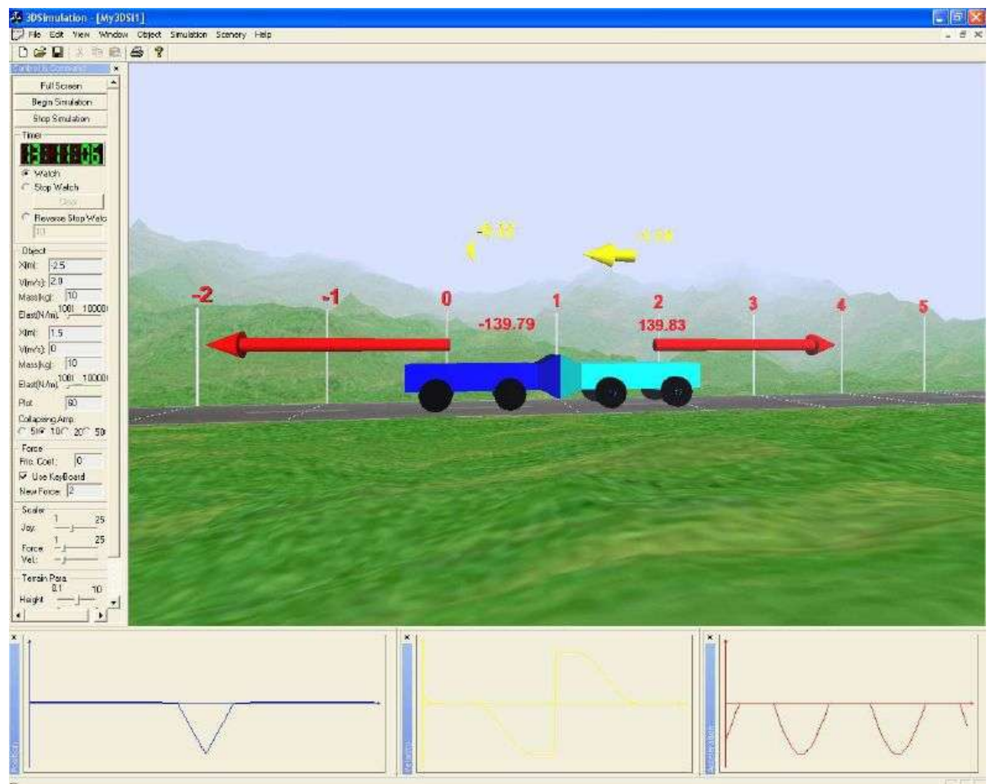


Trials: Circular Motion

- This simulation was presented to a calculus-based intro class as a lecture demonstration.
  - lecturer did an example run, during which the force vectors were turned off so as to not give away the answer
  - class was polled for ideas: how to move it along a circle?
  - two volunteers with opposing ideas went to the front of the room to test them, and the class chose a "champion"
- Student response and interest during the demo was excellent. They laughed, cheered, etc..
- In their weekly survey, most students said the sim. was helpful, and that they would like to see more.

Trials: 1-D Collisions

- Two simulated carts can be controlled. When they collide, slow-motion begins and the carts distort, showing details of the collision process that are usually glossed over.
- All cart properties such as mass and elasticity can be changed.
- Plots, force and velocity vectors, etc..



Trials: 1-D Collisions

- Software tested with seven calculus-based intro students working in small groups.
- A tutorial or “lab”-like activity was prepared.
  - four collisions were studied with varying masses, elasticities, and initial velocities
  - students were asked to predict graphs, maximum forces, and the instant where the carts have the same velocity
- Because these “microscopic” processes are rarely addressed, students showed great cognitive conflict.
  - many incorrect predictions led to much discussion after each simulated collision

Wider Implementations

- Response to the VE simulations has been positive in each trial, and in informal trials during “open houses”.
- We are developing modules to accompany the simulations which will be implemented into our introductory course labs starting next quarter.
  - this will provide our first opportunity to test the simulations on a large body of students
- A fourth simulation dealing with motion on inclined planes is in development.