When Does Immersion in a Virtual Environment Help Students Construct Understanding?

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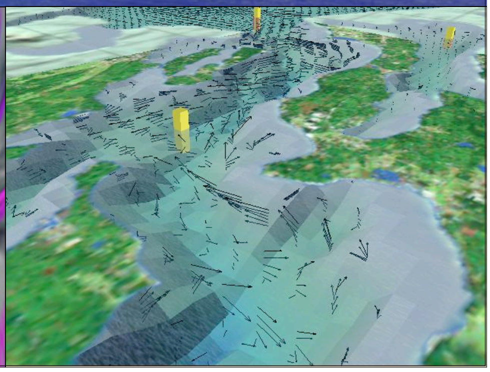
Objective: To test the assumption that immersion in a Virtual Environment helps students understand complex phenomena more than interacting with a non-immersive desktop environment.



Theoretical Framework:

- Factors that might be associated with "adding value" to an immersive VE:
  1. Conceptual change strategies.
  2. Presence.
  3. Transduction.
- Interface affordances:
  - Natural action.
  - Circumambience of experience.

1. Conceptual change.

- Experience events not predicted by current conceptions.
- New experience must be understood.
- New experience must be believable and accommodated.
- New experience must be useful in solving new problems.
- All this should occur in an interactive environment that allows experimentation.

(Windschitl & André, 1998)

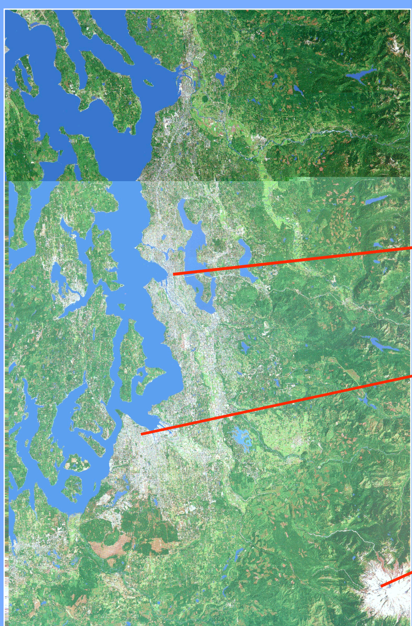
2. Presence.

- Direction of attention to the VE and away from the real world by:
- Reduction of distraction.
  - Hardware, lab./classroom setting.
- Engagement in the VE.
  - Computer games:
    - Challenge, curiosity, fantasy, (Hedden, Malone, Lepper).
    - "Flow" (Csikszentmihalyi).
  - Ecological views of learning:
    - Embedding student in the VE, (Clark).
    - Self-organization of a single student-environment system, (Beer).

3. Transduction.

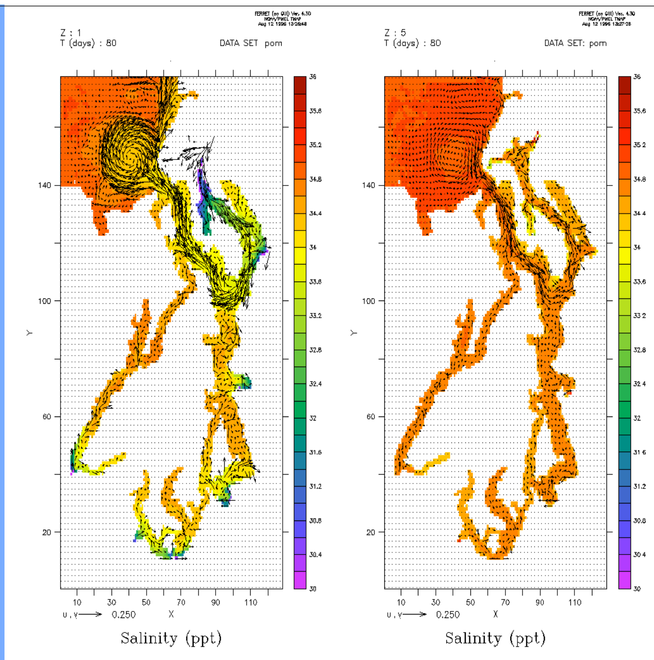
- Extension of the "bandwidth" of the human senses.
- Possible, because all experiences in a VE are created from digital data.
- Transduced information can only be experienced through metaphor.
  - Helps knowledge construction.
  - BUT … can induce misconceptions.

"Real" Puget Sound

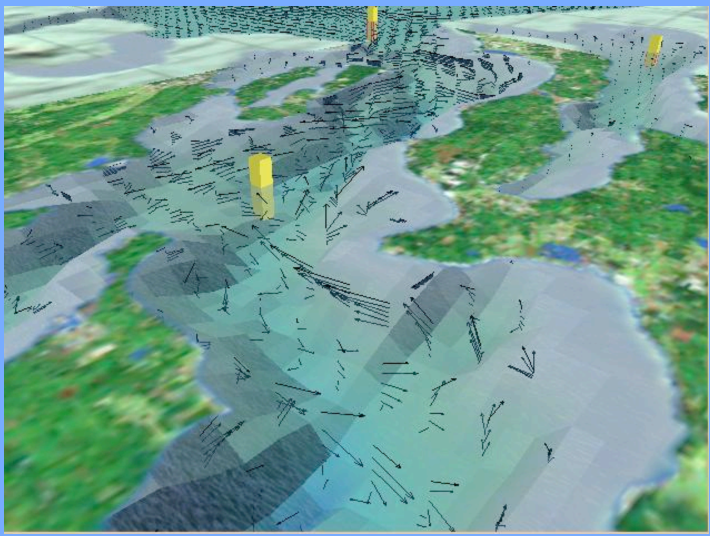


Virtual Puget Sound (VPS)

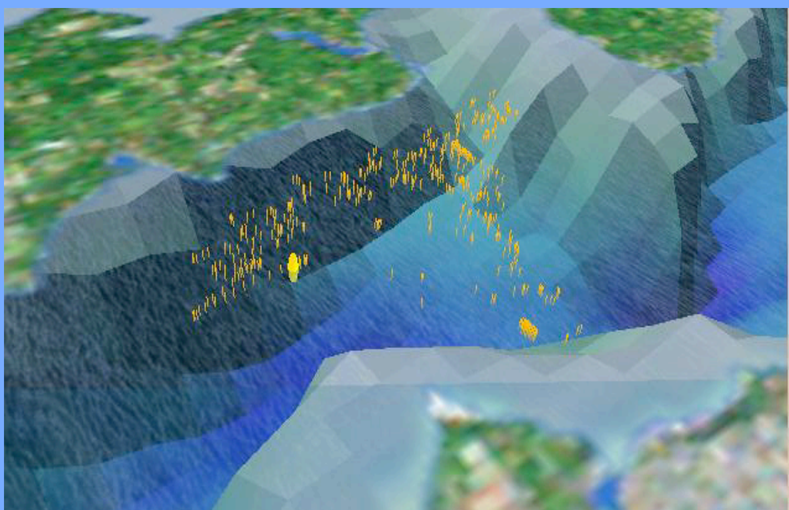
- Simulation of tides, currents and salinity in Puget Sound.
  - One tidal cycle – roughly 24 hours.
  - Data produced for 12 depths at each point on a 600 by 900 meter grid.
  - "Truthed" from RV *Thompson*.
- Two versions:
  - Vector metaphor for water movement.
  - Particle advection metaphor.
- Gesture and game controller interfaces.



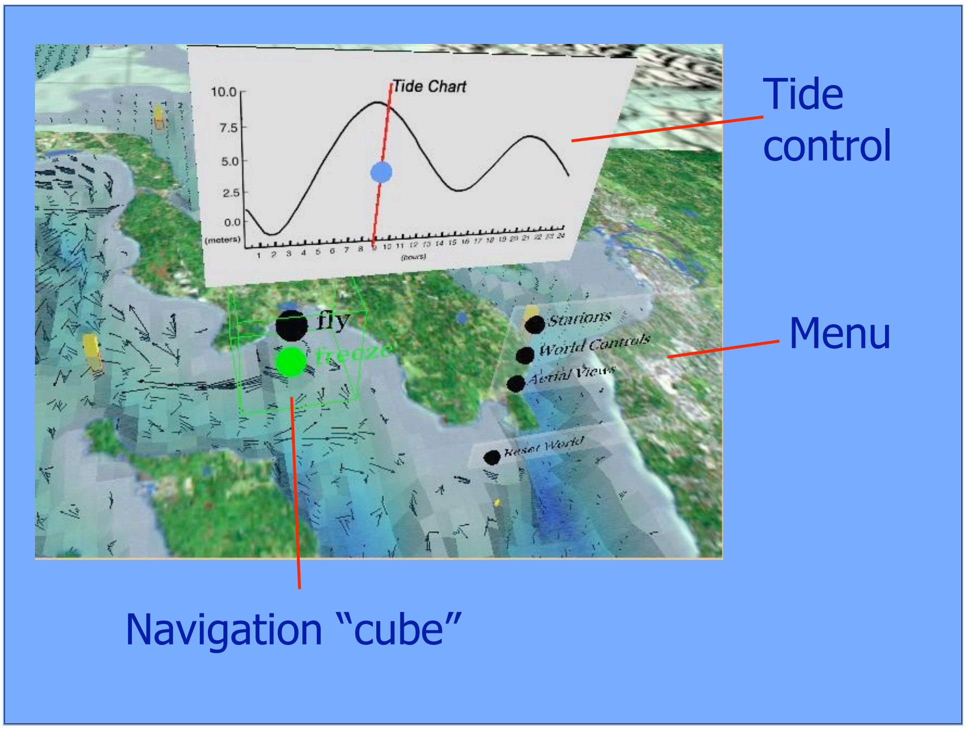
Salinity and current dataset

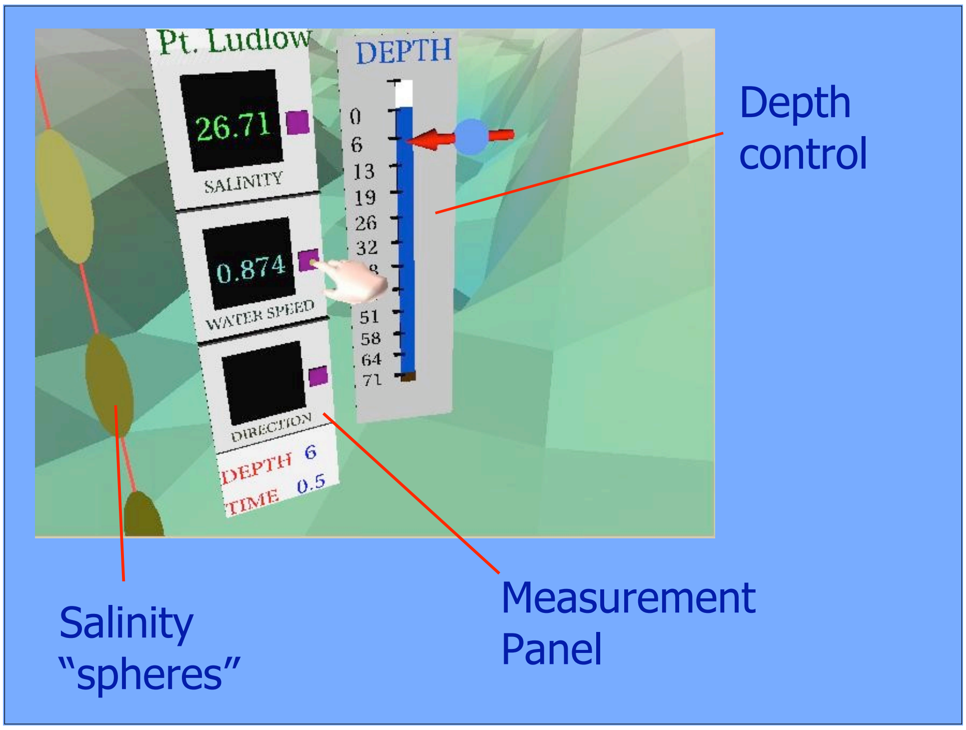


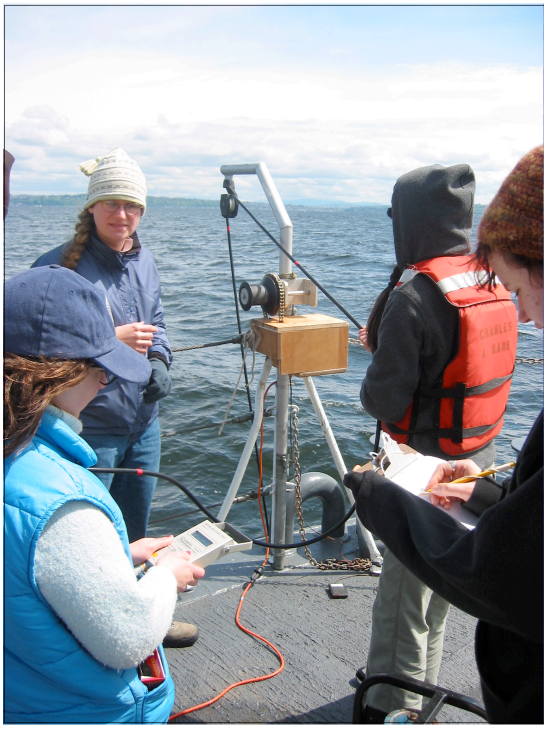
The “vector” metaphor for currents.



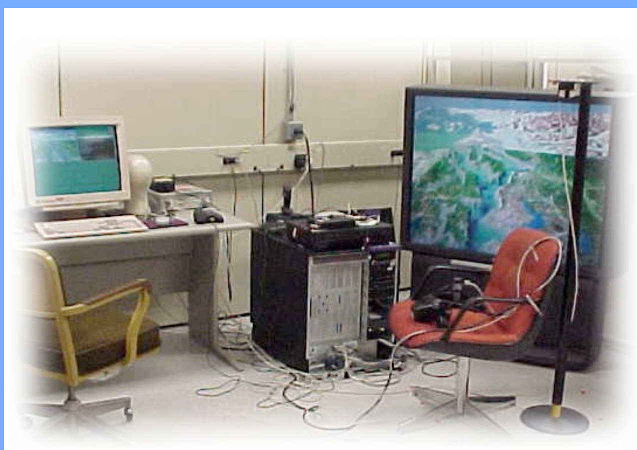
Particle advection shows water movement.


Tide Chart
10.0
7.5
5.0
2.5
0.0
(meters)
(hours)
fly
Stations
World Controls
Aerial Views
Reset World
Tide control
Menu
Navigation "cube"


Pt. Ludlow
26.71
SALINITY
0.874
WATER SPEED
DIRECTION
DEPTH 6
TIME 0.5
DEPTH
0
6
13
19
26
32
51
58
64
71
Depth control
Salinity "spheres"
Measurement Panel



Doing it for real aboard a research Vessel.



The experimental setup

Student and experimenter

The study:

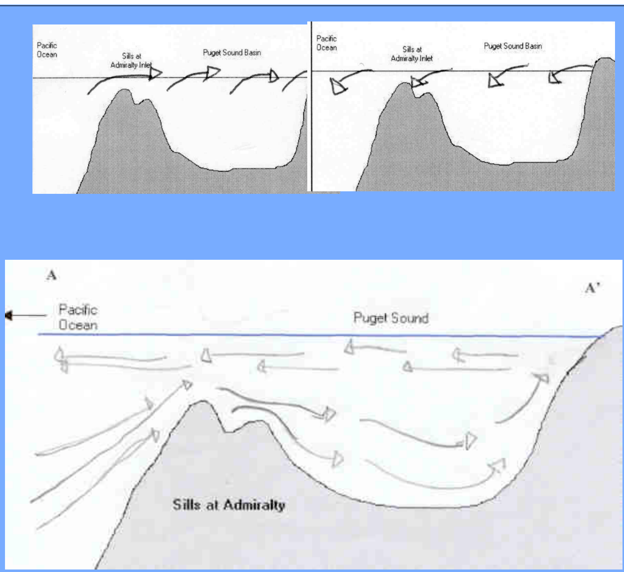
- Students: Twenty-six undergraduates in Computer Science and Information Science assigned in equal numbers to "immersive" and "desktop" treatments.
- Task: Recommend to King County where to site the discharge pipe for treated sewage from a new treatment plant.

The study:

- Procedures and data sources:
  - Questionnaire and pretest over content.
  - Training on environment and interface.
  - Three iterations of:
    - Predict, on a map, how particles would move when released at different places, depths and in different patterns.
    - Visit VPS and release particles to test predictions.
    - Account for what you observed.
  - Requests for explanations during visit.
  - Interview, debrief.
  - Posttest.
  - Event logs.
  - Videotapes.

Findings:

- Quantitative data, all p's <.05, unless otherwise noted:
  - Immersed students learned more about water movement than desktop students, but not about the tidal cycle and salinity.
  - Immersed students were better at picking an appropriate site ($p < .10$).
  - Immersed students rated presence higher than desktop students.
  - Rated presence predicted posttest scores.



Pre- and posttest drawings of vertical circulation by a Middle School student

Findings:

- Qualitative data, conceptions changing:
  - Relationships among water depth, speed, direction, salinity, and particle release point.
  - No obvious differences in the moments of conceptual change between immersed and desktop students.
  - Some other differences in behavior.

Immersed student.

"… looks like the ones moving the fastest are the ones close to the shore on the West … and they're pretty slowly moving to the North." [Referring to the particles close to the East shore] "… Yeah, looks like they're pretty stagnant, they didn't move very far, and looks like there's really shallow water right there … Yeah, the ones on the East side approach the shore, the ones on the West move basically to North."

Desktop student

"The four yellow dots on the left are moving in the same sort of movement, up and down, up and down. But when it's close to shore, you know, the water seems to be moving much towards East a little bit … and of course they're not moving as much, I guess."

Other observations

- Immersed students looked around much more than desktop students.
- Non-immersed students often pointed directly at the screen as they were explaining something (deictic gestures). (Immersed students could not do this.)
- Immersed students took longer.
- Immersed students said more.

Conclusions.

- Immersion in a VE helps students understand dynamic, three-dimensional phenomena by observation. Interacting with an equivalent desktop environment is sufficient for them to learn about things described by virtual instruments.
- Heightened presence, fostered by curiosity and challenge (& fantasy), improves learning.