# P689: Why don't fish die in the Winter?

Using 3D magnetic models to visualize particulate level arrangements of water

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# Kenowa Hills High School

- Grand Rapids Michigan
- 1200 students
- 11th grade chemistry
  - Students required to take physics or chemistry
  - No tracking of students thus far
- 24 chemistry students of a range of abilities

# Problem

- Students weren't understanding the reasons why things happened in chemistry
- No connections between observed events and molecular structure

# Research Goal

- Can three dimensional haptic models improve students' understanding of the particulate nature of water.

# Objectives

- Students will be able to explain why lakes don't freeze all the way through in the winter.
  - Nature of hydrogen bonds in water
  - Effects of intermolecular forces on density, surface tension etc.
- Students will be able to describe and explain the differences in solubility of ionic compounds and gases at different temperatures
  - Again effects of intermolecular forces on solubility

# Guided-Inquiry Instruction

- Students are not passive learners
- Constructivist Approach
- Better gains and retention
- Research Backed
  - Bridle & Yezierski (2011)
  - Hewson & Hewson (1983)
  - Lewis & Lewis (2005)
  - Üce (2009)
  - And many more

# Why Fish?

- I'm from the "Great Lake State"
  - Lots of my students fish for recreation
- Gives a real world impact of a chemistry concept
- Rigor & Relevance
  - Particulate chemistry is hard enough to supply rigor
  - Fish provide relevance to the students lives

# The Models – If you have a great idea, chances are someone else has already had the same one!

## My Prototypes

- Time consuming
- Not very pretty
- Not as durable

## The "Competition"

- Costs about the same
- Almost Zero Time
- Durable

# Three Dimensional Models

- Why use three dimensional models?
  - Interactivity
  - Hands-On
  - No computer access required
  - Engage all students
  - Evidence of effectiveness
    - Huddle & White (2000)

# Haptic Feedback

- Touch Sensory Feedback
- Why a haptic model?
  - No need to explain interactions they can feel
  - Forces not easily observable or memorable in drawings or animations
  - Reduces Cognitive Load
    - Jones et. al (2005)
    - Individuals can only process so much information of one type

# The Prelab

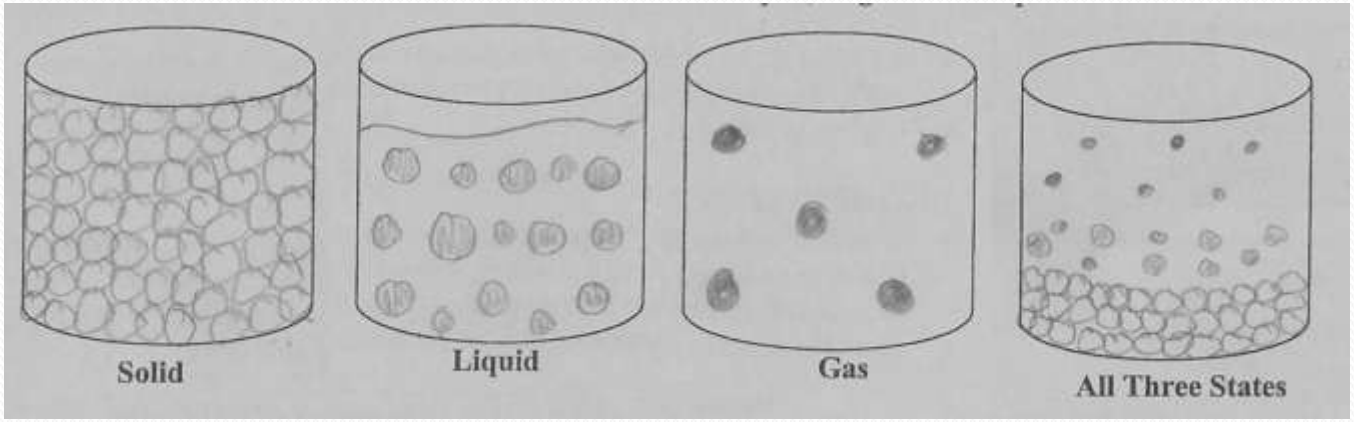
- "The Price is Right" Introduction
  - Intro into the idea that water has unique properties
  - Run as a quick game show, how many pennies can you fit in the cup without going over.
  - Demonstrates high surface tension of water
- Other introductions
  - Floating paper clips
    - Two cups, one with a little detergent, or one with oil
  - Drops of water on a penny

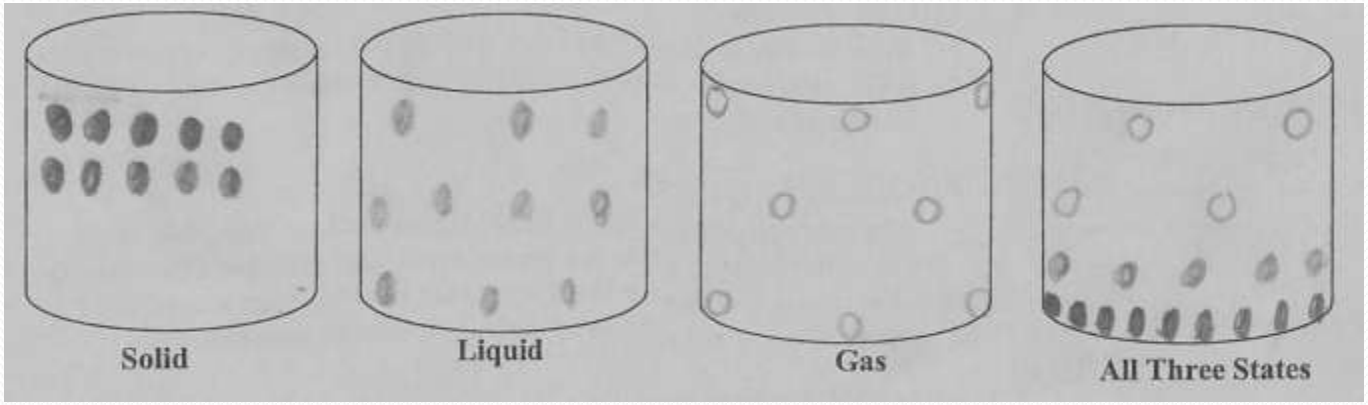
Soon to be dead fish…
but he was fine before!

# A Fishy Problem

- The Challenge – Why don't fish in lakes/ponds die in the Winter?
- I'm from Michigan our smaller lakes/ponds freeze over solid most years, sorry if you don't get to experience the bitter cold where you're from.
  - Brainstorming session (group & share)
    - Typical answers
      - Water is too cold, fish are cold blooded
      - They should suffocate, lake is frozen over (fish breathe oxygen)
      - Lack of food

# Typical Particulate Drawings of Different States of Matter



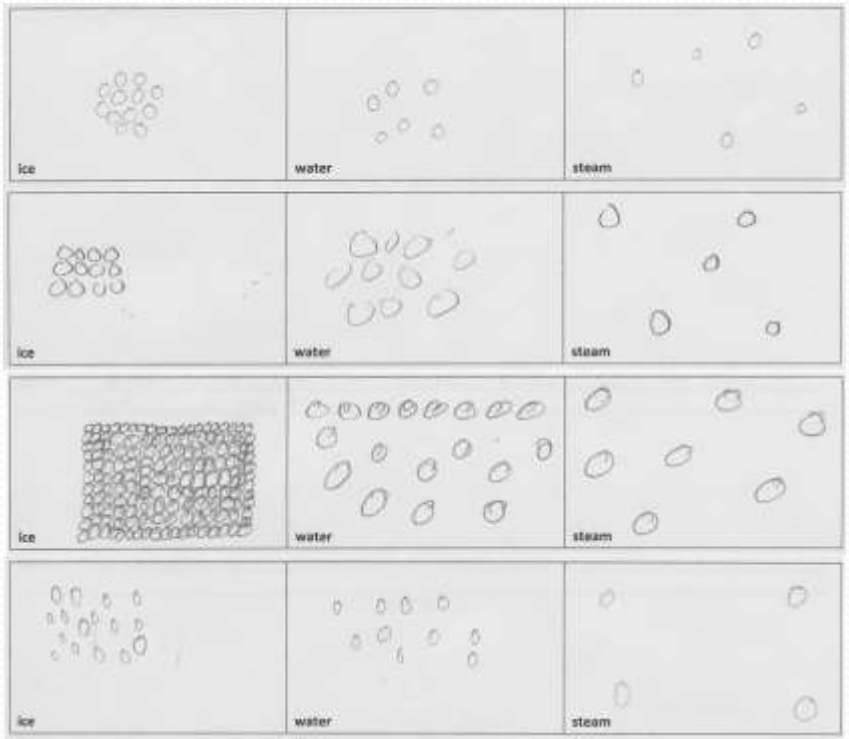
# What's Wrong With This Picture?

# Using the Models

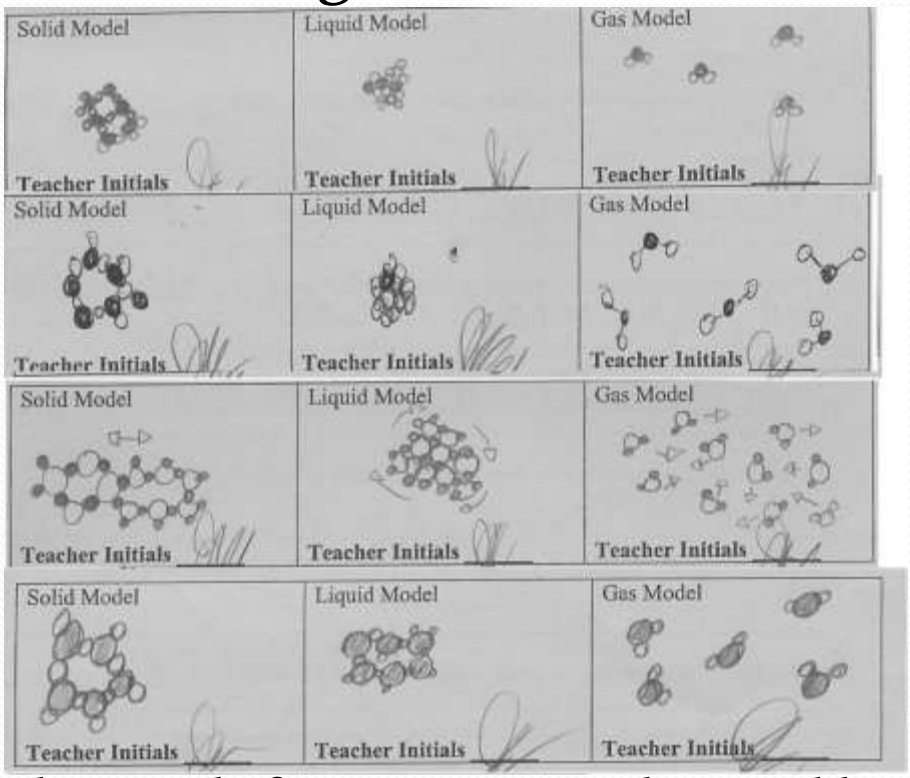
- Students use the models to demonstrate each of the states of matter and the type of motion each experiences using their hands (and a CAPPED! Ice cream pail for gas)
- They then draw what they actually see and feel.
  - This is a good time to prod them and make sure they can explain the differences they see.
  - Some students will go into autopilot and redraw the pictures they had before, I always ask to see what they have drawn with the model.

# Student Data

- Drawings 2days prior




- Drawings with models




Note: Student's still draw ice, water, steam, the same before treatment as they would any other solid, liquid, gas. In retrospect I wish I had asked them to draw all three together to see what they did (and next year I will).

# Stats

**Coding**
**0=absent**
**1=incorrect**
**2=partially correct**
**3=correct**

| | N | Mean Pre | SD Pre | Mean Post | SD Post | P-Value | Significance |
|---|---|---|---|---|---|---|---|
| **Particle Spacing** | **20** | **1.40** | **0.88** | **2.95** | **0.22** | **<0.0001** | **extremely** |
| **Particle Arrangement** | **20** | **1.90** | **1.21** | **2.95** | **0.22** | **0.0016** | **very** |
| **Molecular Representations** | **20** | **0.90** | **1.41** | **2.60** | **0.50** | **<0.0001** | **extremely** |
| **Bond Angle** | **20** | **0.30** | **0.47** | **2.60** | **0.68** | **<0.0001** | **extremely** |
| **Molecular Orientation** | **20** | **0.30** | **0.47** | **2.90** | **0.31** | **<0.0001** | **extremely** |
| **Particle Movement** | **20** | **0.00** | **0.00** | **1.00** | **1.08** | **0.0005** | **extremely** |
| **Total Drawing Score /18** | **20** | **5.00** | **2.70** | **15.00** | **1.65** | **<0.0001** | **extremely** |

# They're not done… How on earth do those Fishies breathe?

- Hopefully their Biology teacher has done their job (unfortunately that's usually me!)
  - Fish breathe oxygen
- If fish breathe oxygen what happens when the lake is frozen over?
- Solubility of ionic (magnetic) and covalent compounds (ping pong balls for gas)

- Students compare solubility based on temperature (speed of shaking)

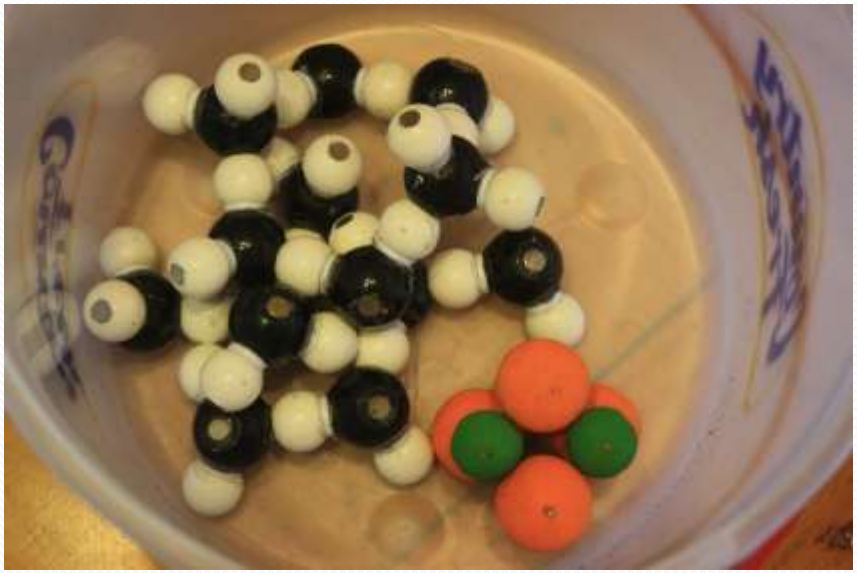
# Tricks for facilitation

- Ask the students to simulate state change together slowly (this is loud) with their ice cream pails
- They have to go slow to see any differences
  - Start with the ionic compound as a solid placed on the "ice"
  - Doesn't dissolve until shaken, more shaking = more dissolving
  - Gases only stay in solution at low temperatures
  - It's rather funny asking them what they think just happened when a ping pong ball flies out of their bucket.

# Facilitation

- What should the particles look like when they are dissolved in the water?
  - Students will drop them in the bucket and tell you they are dissolved without them being dissociated

## Not Dissolved



## Dissolved

TARGET INQUIRY:
Improving High School Chemistry

- Website
  - www.gvsu.edu/targetinquiry
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# Any Questions?

- Going Further
  - How do fish cope with the cold temperatures (what does that do to chemical reactions?) or how do fish keep from freezing themselves?
  - Water at 4 degrees Celsius is the most dense form of water. Look at the diagram of the lake below. What will happen in the lake as the temperature of the lake increases in the spring, i.e. the sun heats the surface of the lake? Why would it be called Spring Turnover?
  - The same effect happens in reverse in the fall (Fall Turnover) as the surface of the lake cools. Why are these two times so important to a lake ecosystem? What does the movement of the water do?