A Nano-Enabled Water Treatment Laboratory To Teach Earth Sciences And Chemistry Through Nanotechnology

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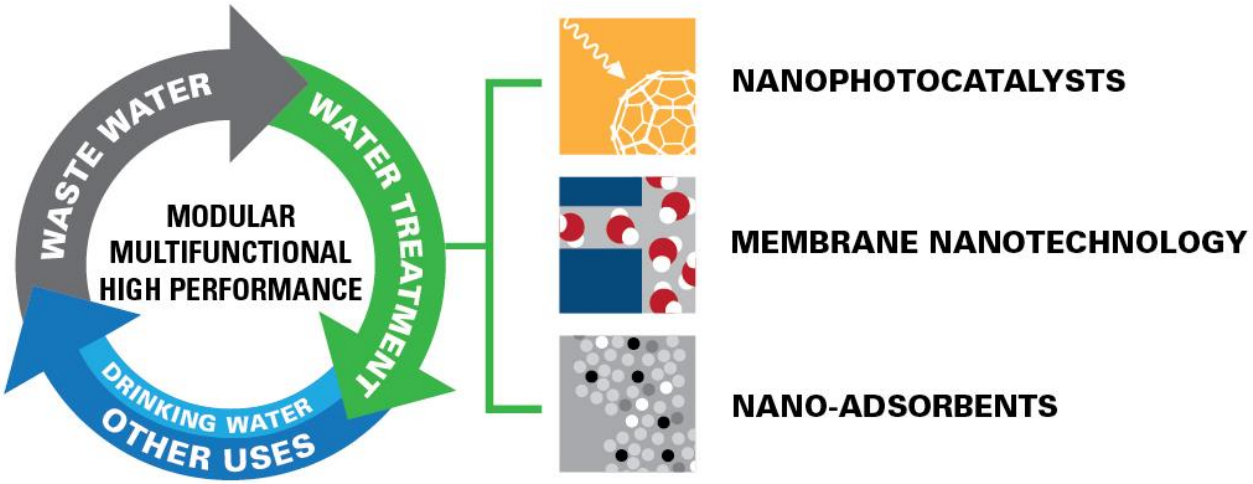
Presentation outline

- NEWT RET program
- Challenges of Nano-Education in High School
- Proposed activity
- Results
- Moving forward

Leap-frogging opportunities to:

- Develop small, high-performance, multifunctional materials & systems that are easy to deploy, can tap unconventional water sources, and reduce the cost of remote water treatment
- Transform predominantly chemical treatment processes into modular and more efficient catalytic and physical processes that exploit the solar spectrum and generate less waste



Focus on Two POU Applications

- Off-grid humanitarian, emergency-response, and domestic **drinking water** treatment systems

https://www.globalgiving.co.uk/projects/clean-water-for-peru/updates/

- Industrial **wastewater reuse** in remote sites (e.g., oil and gas, offshore platforms)

http://switchboard.nrdc.org/blogs/rhammer/fracking-2.jpg

Public acceptable of Nanotechnology

Concerns from the public and the scientific community over the risks of nanotechnology

Are carbon nanotubes safe?

Zhao *et al*., *Nature*, 2008

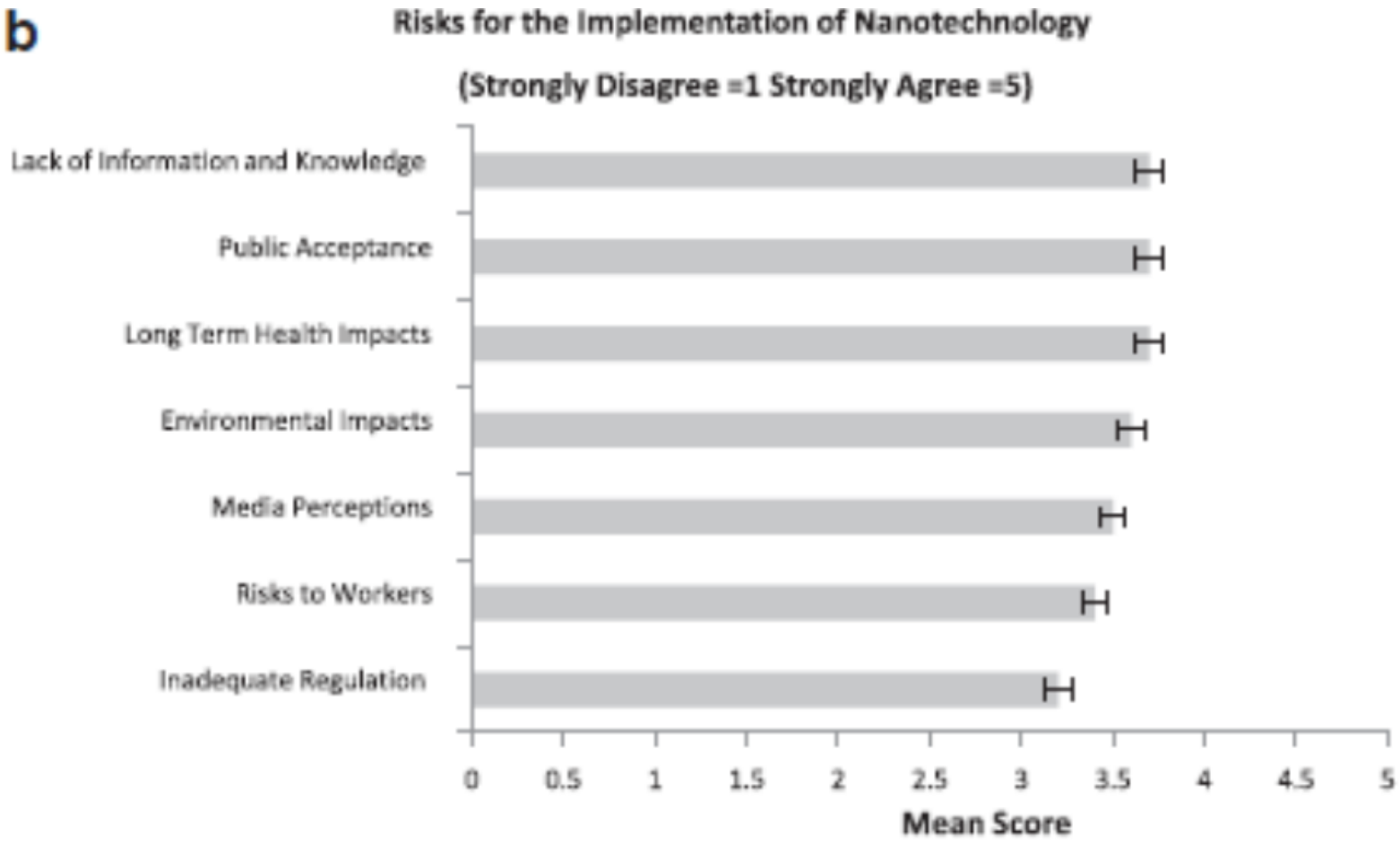
EPA Needs to Manage Nanomaterial Risks More Effectively

US EPA report 12-P-0162, 2011

The challenges of nanotechnology risk management☆

Fadel et al. *Nano Today*

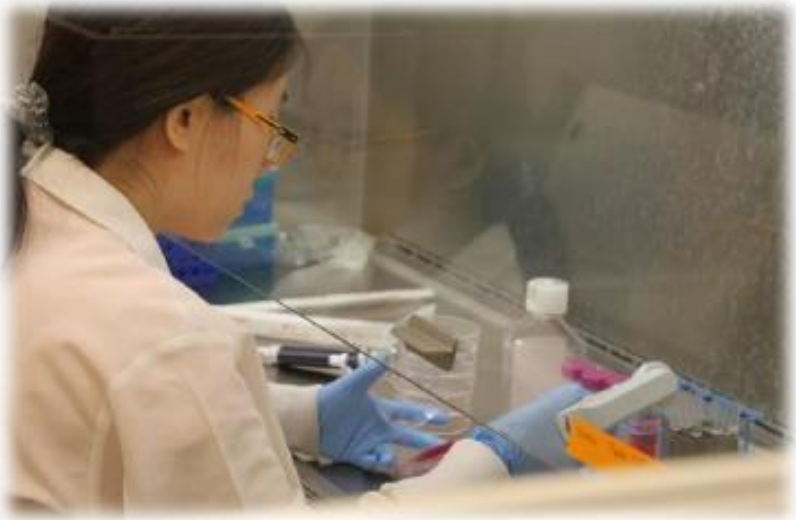
Why people fear nano?

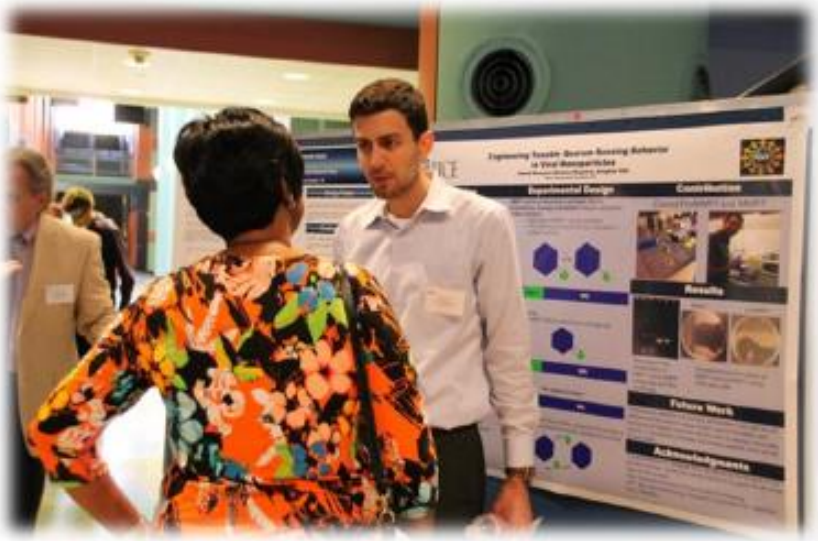


Public knowledge and public perception are often considered barriers to the implementation of nanotechnology

Handford et al. Food Control 2015

NEWT RET program





Secondary science teachers and faculty from partner community college spend 10 weeks in NEWT labs to

- Conduct nanotechnology research
- Develop new nano-themes educational activities

Challenges

Practical

- Small lab budgets
- Limited lab time (~1h)
- Hazardous chemicals should be avoided

Educational

- Small or no background knowledge
- Nanotechnology is not on the curriculum

not a lot of time to spend on it

What's on the curriculum?

Concept 1: Structure and Properties of Matter
Understand physical, chemical, and atomic properties of matter.

PO 1. Describe substances based on their physical properties.

PO 2. Describe substances based on their chemical properties.

PO 3. Predict properties of elements and compounds using trends of the periodic table (e.g., metals, non-metals, bonding – ionic/covalent).

PO 4. Separate mixtures of substances based on their physical properties.

PO 5. Describe the properties of electric charge and the conservation of electric charge.

PO 6. Describe the following features and components of the atom:

- protons
- neutrons
- electrons
- mass
- number and type of particles
- structure
- organization

PO 7. Describe the historical development of models of the atom.

PO 8. Explain the details of atomic structure (e.g., electron configuration, energy levels, isotopes).

What's on the curriculum?

Concept 1: Geochemical Cycles
Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.

PO 1. Identify ways materials are cycled within the Earth system (i.e., carbon cycle, water cycle, rock cycle).

PO 2. Demonstrate how dynamic processes such as weathering, erosion, sedimentation, metamorphism, and orogenesis relate to redistribution of materials within the Earth system.

PO 3. Explain how the rock cycle is related to plate tectonics.

PO 4. Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.

PO 5. Describe factors that impact current and future water quantity and quality including surface, ground, and local water issues.

PO 6. Analyze methods of reclamation and conservation of water.

PO 7. Explain how the geochemical processes are responsible for the concentration of economically valuable minerals and ores in Arizona and worldwide.

Objective: Teach nanotechnology concepts through a nanotechnology and water treatment laboratory while supporting the current curriculum

Experiment

Journal of Materials Chemistry A

RSC Publishing

PAPER

One pot synthesis of magnetite–silica nanocomposites: applications as tags, entrapment matrix and in water purification†

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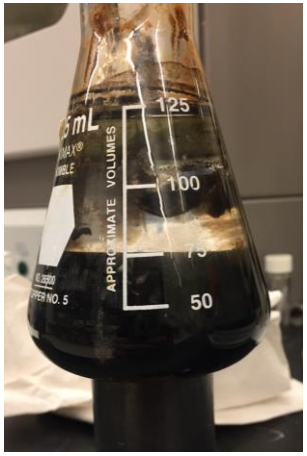

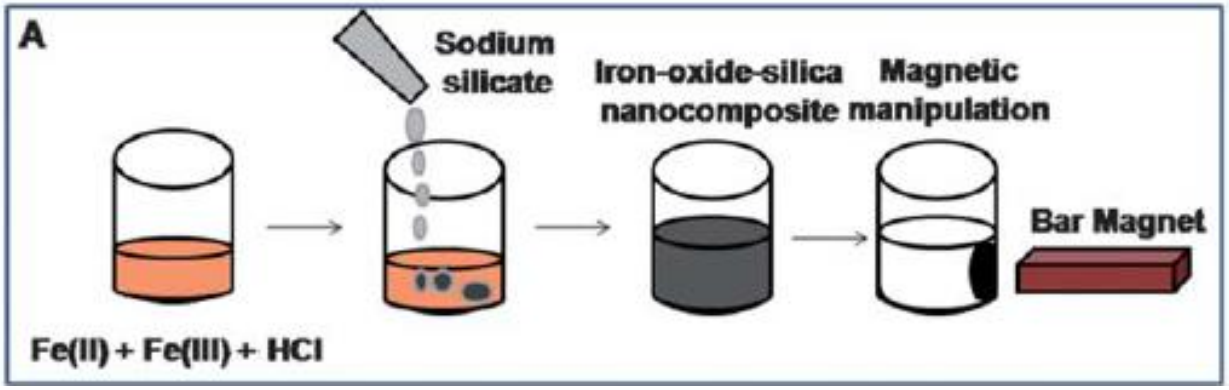

Two session lab activity

1. Synthesis of nano-magnetite
2. Removal of a model contaminant (methylene blue)

Evaluation

Pre-lab

1. What are some major sources for water contamination within the state?
2. What methods do you think we could use to clean the water?

Mid-lab

1. Describe the evidence of chemical reactions occurring while creating the mineral.
2. What mineral do you think you created? Hint: use the colors you saw in the solution and the formula for the two salts and the textbook.
3. How do you think it will clean contaminates out of water?
4. How will you remove the mineral and contaminates from the water?

Post-lab

1. Describe some locations or scenarios where this form of water purification could be used.
2. How is what you did a form of nanoengineering?
3. What fields of science seem important for nanoengineering?
4. How is what you did a form of environmental engineering?
5. What fields of science seem important for environmental engineering?

Concepts covered

Concept 1: Geochemical Cycles
Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.

PO 5. Describe factors that impact current and future water quantity and quality including surface, ground, and local water issues.

PO 6. Analyze methods of reclamation and conservation of water.

Concept 1: Structure and Properties of Matter
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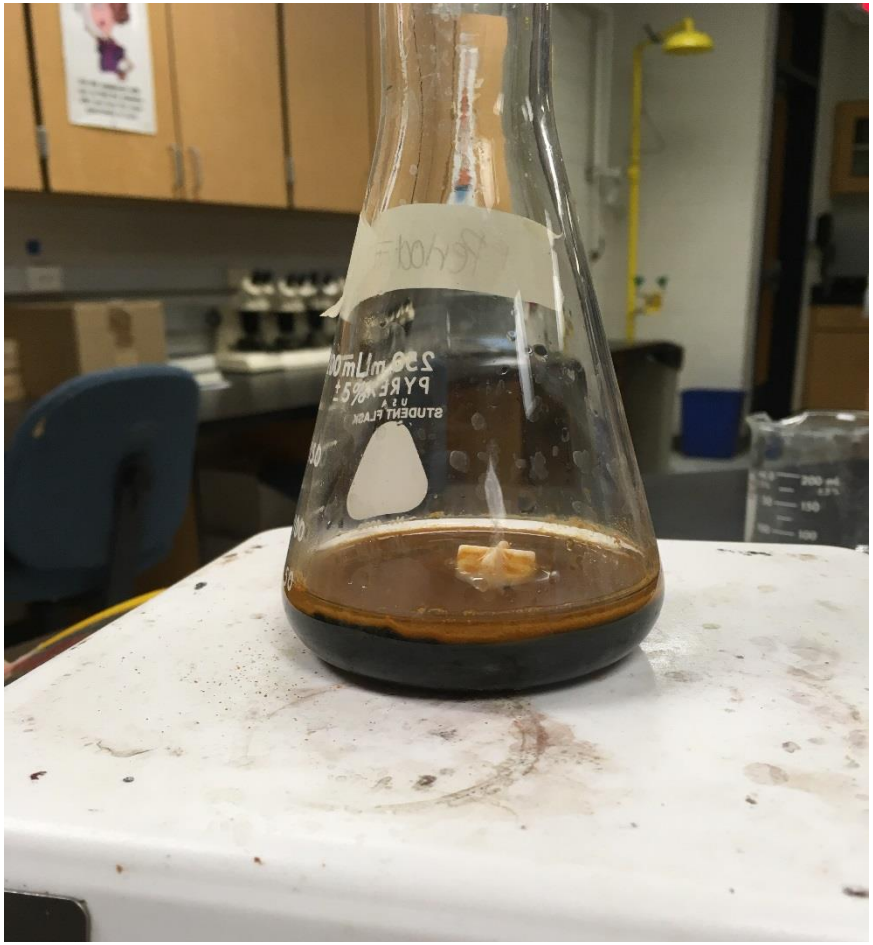
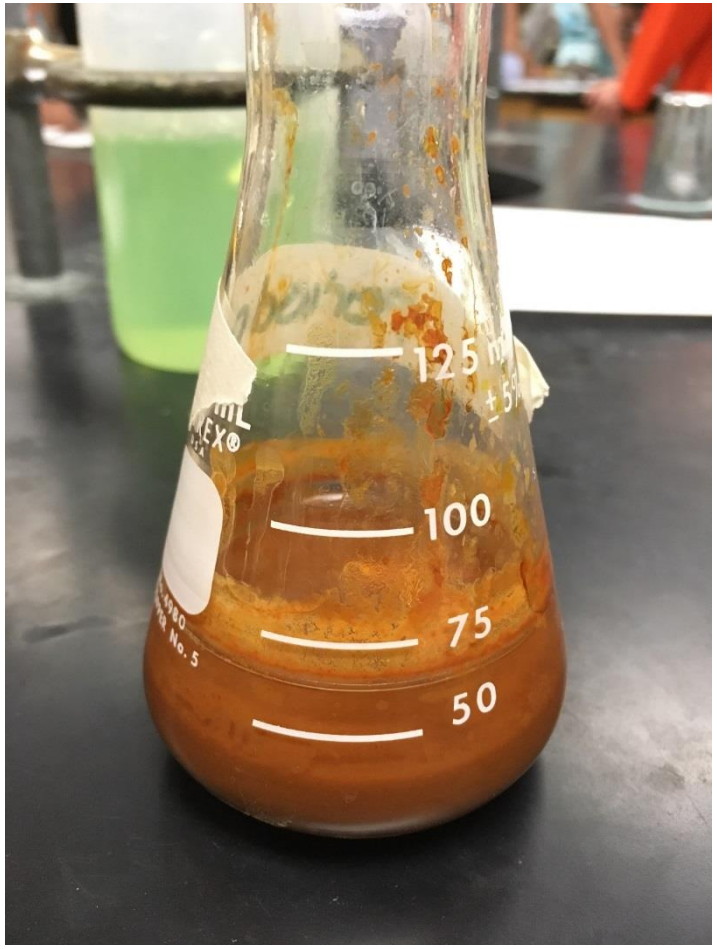
PO 4. Separate mixtures of substances based on their physical properties.

Synthesis





Successful synthesis can be clearly visualized after the reaction.
- Visual correlation between the nature of the material and its properties.

Evaluation

1. Describe the evidence of chemical reactions occurring while creating the mineral.

changed color, became turbid, formed a solid.

2. What mineral do you think you created? Hint: use the colors you saw in the solution and the formula for the two salts and the textbook.

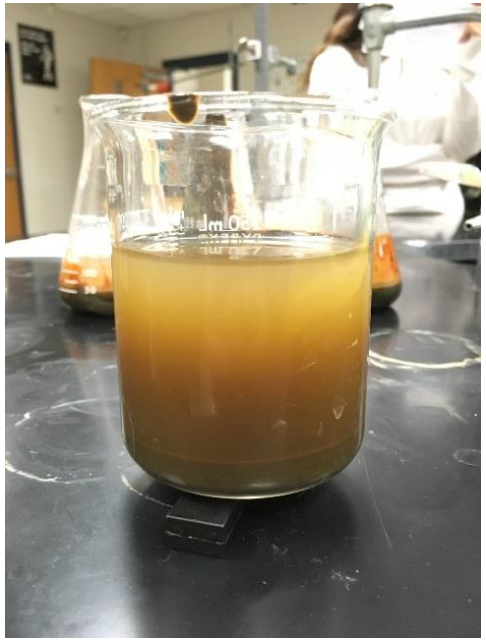
Iron-based mineral

3. How will you remove the mineral and contaminates from the water?

Using the magnetic properties of the material

Magnetite

Adsorption experiment



- Large variation in the performance of the different synthesis.
- All black material removed MB quite well, but not all responded well to the magnet.

Evaluation

1. Describe some locations or scenarios where this form of water purification could be used.
   - *Oil spills*
   - *Lake water purification*
   - *Areas with metallic pollutants/rust*
   - *Poor areas*

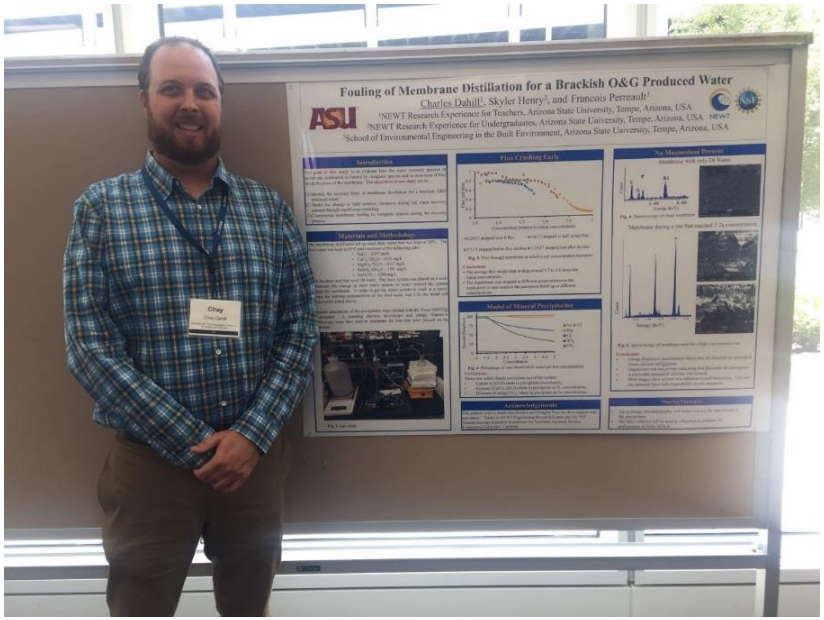
2. How is what you did a form of nanoengineering?
   - *Made a chemical compound/reaction to purify water*
   - *Made something at the atomic scale*
   - *Particles of iron come together to separate metals from water*

3. What fields of science seem important for nanoengineering?
   - *Chemistry was the most common answer*
   - *Environmental sciences*
   - *Earth sciences*

Conclusions and next steps

- A nanotechnology lab was developed and tested
- Fits in the curriculum and appropriate for a high school settings
- Students were able to express what happened in clear, explainable ways
- Need to make the reaction more robust
- Expand the discussion to include applications of nanotechnology to other fields

Acknowledgements



Acknowledgements

Thank **you**!

Example of answers

Pre-lab

1. What are some major sources for water contamination within the state?

   -factory waste, oil pollution, sewage, river dumping, agricultural pollution, dead animals"

2. What methods do you think we could use to clean the water?

   - Filtration

   - Boiling/distillation

   - Chlorine

Students are aware of common sources of contamination for water, and of some conventional methods for water treatment