Education of Nanotechnology with Problem Based Learning (PBL)

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Abstract. *Problem based learning in Nano education increase thinking skills and clear uncertain point of mind and established connection between scientific concepts and consequently, we could move in upper border between scientific education for learners and given scientific learning. The physical and chemical properties of matter can often give us insight into chemical reactivity and behavior. We will implement the PBL pedagogy to learn about "Matter" unit through the real-world application of Nanotechnology in the real life. This research survey way of PBL, and using of it for Nanotechnology, so that students could understand given clues perfectly and, so study how assesses learners correctly.*

Key word. Problem solving train, Nano particles Nanotechnology

1. Introduction

The year is 1959. Caltech physics professor and Nobel Laureate (1965), Richard P. Feynman delivers a stunning lecture on the possibility of science research from the bottom up. The lecture, cleverly titled, "There is plenty of room at the bottom", suggests that there are no limits on producing things from the atomic level up. He is quoted as saying, "The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom." The questions that arose from these lectures were many. But did Feynman really set the spark towards nanotechnology. In 1808, John Dalton, a British Chemist claimed that every single atom of a certain element, is identical. This idea will become Very important later in this perspective. In 1868, Gregor Mendel, A Czech Monk, characterized the structures and functions of heredity. Surely, both of these scientists could not have foreseen what we would do with their work. Probably the most daunting task was to build devices that would allow us to see things that are on the atomic size. The term, "Nano-" itself means a billionth of a meter.This is 100,000 times smaller than a human hair. Feynman suggested in his lecture that we build better microscopes to accomplish the task of seeing things on the atomic level. It wasn't until 26 years later (1981) that we invented the Scanning Tunneling Electron Microscope. This device is widely used in industrial and fundamental research to obtain images of metal surfaces at the atomic scale. It allows us to produce a 3-D profile of the surface, which we can use to characterize roughness, defects, size, and conformation of molecules. The device basically works by placing an atom at the bottom of a very sharp tip of a needle. This needle is brought within close proximity of the surface being tested. Electrical voltage is then applied to the tip. The tip then interacts with the electron clouds on the metal surface. As the distance changes so does the current flowing between the tip and the surface. These changes can then be converted into an image. And thus the ability to work at the atomic scale exploded. It is pretty amazing to think that a lump of coal and a diamond are made of exactly the same chemical: carbon. The only difference is how the atoms are arranged. What would happen if we could manipulate the carbon atoms and manufacture diamonds as easily as M&M's? This certainly raises some questions about how our economic system might change in the near future. One interesting discovery on maneuvering carbon atoms around was in 1985. Scientist Richard Smalley and fellow researchers were able to construct a cage of 60 carbon atoms. It certainly appears that Dalton's basic theory has opened a

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door for us to fabricate endless things with basic raw elements.

On November 9, 1989 at IBM's Almaden Research Center in San Jose, California, scientists Don Eigler and Erhard Schweizer began a little atomic manipulation project of their own. With company pride they manipulated 35 Xenon atoms to form the logo, "IBM". And thus the era of Nanotechnology began.

2. Nanotechnology and the National Science Teaching Standards

Below are the National Standards:

✓ Science Content Standards 9-12

- Structure of Atoms
- Structure and properties of matter
- Chemical Reactions
- Motion and Forces
- Conservation of Energy and increase in disorder (entropy)
- Interactions of energy and matter

✓ Science and Technology Standards

- Abilities of technological design
- Understanding about science and technology

✓ Science in Personal and Social Perspectives

- Personal and Community Health
- Population Growth
- Natural Resources
- Environmental Quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

✓ History and nature of science standards

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspective

The physical and chemical properties of matter can often give us insight into chemical reactivity and behavior. This unit focuses on the properties and classification scheme used in science to distinguish between different types of matter. We will implement the problem-based learning (PBL) pedagogy to learn about "Matter" unit through the real-world application of Nano technology.

3. Lesson Scopes

Below is a brief outline of the scope and sequence of lessons in this unit:

i) Real world science and engineering applications
ii) Educational technologies to build content knowledge
iii) Information technologies for communication, community-building and dissemination
iv) Cognitively-rich pedagogical strategies
v) STEM education and careers investigations.

The lessons can be tailored to include your own common successful instructional strategies.

✓ Lesson 1: Introduction to PBL
✓ Lesson 2: What is "Matter"?
✓ Lesson 3: States of Matter / Phases Changes between States
✓ Lesson 4: Pressure Volume & Temperature / Boyle's Law
✓ Lesson 5: Physical vs. Chemical Changes
✓ Lesson 6: Physical and Chemical Properties
✓ Lesson 7: Nanotechnology Applications
✓ Lesson 8: Experiment
✓ Lesson 9: Assessment

4. Lesson Plan:

4.1 Lesson 1: Introduction to Problem-based Learning (PBL)

What is PBL?

With problem-based-learning (PBL), your teacher presents you with an "ill-structured" problem that has many factors that need to be considered and several possible ways of solving the problem. Since you are not handed the solution, your learning becomes active in the sense that you discover and work with the ideas that are presented in class combined with the research that you conduct individually and in collaboration with peers. Then, you and your peers make important decisions regarding what aspects of the available information are critical for you to solve the problem and craft a solution.

Essential characteristics of PBL:

1. Students must have the responsibility for their own learning (self-directed learning).
2. The problem scenario used in PBL must be ill-structured and allow for free inquiry.
3. Learning should be integrated from a wide range of disciplines or subjects.
4. Collaboration is essential.
5. What students learn during their self-directed learning must be applied back to the problem with reanalysis and resolution.
6. A closing analysis of what has been learned from work with the problem and a discussion of what concepts and principles

7. Self and peer assessment should be carried out at the completion of each problem and at the end of every curricular unit.
8. The activities carried out in problem-based learning must be those valued in the real world.
9. Student assessments must measure student progress towards the goals of problem-based learning.

PBL will provide you with opportunities to:

1. Use technology to examine and try out what you know.
2. Discover what you need to learn.
3. Develop ethical decision-making skills.
4. Improve your communications and social network skills.
5. State and defend positions with evidence and sound argument.
6. Present collaborative solution.
7. Practice skills that you will need after your education.

You may ask your student to work in group and to have some group discussion on problem by PBL.

Presenting an "Ill-structured" Problem:

"The Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for Scholars has just put up a new Web site with a searchable list of 212 commercially available nano-products. Thirty-one of those products are cosmetics, which contains tiny nano-capsules full of chemicals. These products claim to be effective in protecting skins from sunshine and aging. But some experts wonder about the safety of highly engineered nanostructures like these. That's because when particles get small, they tend to develop new chemical properties. That might mean unexpected risks. Now your group is contacted by the center to help with their investigation on determining whether the nano cosmetics should be on market".

4.2 Lesson 2: What is "Matter?"

Guiding questions to make connections between matter and nano scale science:

1. What is "Matter?" Give two examples of matter and two examples of non-matter.

"Matter is everything that takes up space and has mass. Matter has different forms / phases: Solid, liquid, gas, plasma, and Bose-Einstein condensates. All matter is made up of small particles (atoms)".

2. What is nanotechnology?

"Nanotechnology is an anticipated manufacturing technology giving thorough, inexpensive control of the structure of matter on a nanometer scale".

3. How small is a nanometer, compared with a hair, a blood cell, a virus, or an atom?

"Nano particle: Particle with one or more dimensions of the order of 100 nm or less"

4. How nano technologies affect the properties of matter?

"Because nano particles exist at a scale smaller than that of human cells, nano particles exhibit different chemical and biological properties than the same materials in larger size".

In tandem with surface-area effects, quantum effects can begin to dominate the properties of matter as size is reduced to the nano scale. These can affect the optical, electrical and magnetic behavior of materials, particularly as the structure or particle size approaches the smaller end of the nano scale. Materials that exploit these effects include quantum dots, and quantum well lasers for optoelectronics. For other materials such as crystalline solids, as the size of their structural components decreases, there is much greater interface area within the material; this can greatly affect both mechanical and electrical properties. For example, most metals are made up of small crystalline grains; the boundaries between the grain slow down or arrest the propagation of defects when the material is stressed, thus giving it strength. If these grains can be made very small, or even nano scale in size, the interface area within the material greatly increases, which enhances its strength. For example, nano crystalline nickel is as strong as hardened steel.

5. What is Nano science? (Ask students to think about "nano" concept)

"Nano science is the name given to the wide range of interdisciplinary science that is exploring the special phenomena that occur when objects are of a size between 1 and 100 nanometers (10^{-9}m) in at least one dimension".

4.3 Lesson 3 & 4: States of Matter / Phases Changes between States

You may ask your students to read the content below:

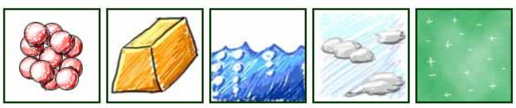

Figure1. Five main states of matter

There are five main states of matter. Solids, liquids, gases, plasmas, and Bose-Einstein condensates are all different states of matter (1).

Each of these states is also known as a phase. Elements and compounds can move from one phase to another phase when special physical forces are present. One example of those forces is temperature. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state. Phase describes a physical state of matter. The key word to notice is physical. Things only move from one phase to another by physical means. If energy is added (like increasing the temperature or increasing pressure) or if energy is taken away (like freezing something or decreasing pressure) you have created a physical change.

One compound or element can move from phase to phase, but still be the same substance. You can see water vapor over a boiling pot of water. That vapor (or gas) can condense and become a drop of water. If you put that drop in the freezer, it would become a solid. No matter what phase it was in, it was always water. It always had the same chemical properties. All matter can move from one state to another. It may require very low temperatures or very high pressures, but it can be done. Phase changes happen when certain points are reached. Sometimes a liquid wants to become a solid. Scientists use something called a freezing point to measure when that liquid turns into a solid. There are physical effects that can change the freezing point. Pressure is one of those effects. When the pressure surrounding a substance goes up, the freezing point also goes up. That means it's easier to freeze the substance at higher pressures. When it gets colder, most solids shrink in size. There is a few which expand but most shrink.

Now you're a cube of ice sitting on a counter. You dream of becoming liquid water. You need some energy. Atoms in a liquid have more energy than the atoms in a solid. The easiest energy around is probably heat. There is a magic temperature for every substance called the melting point. When a solid reaches the temperature of its melting point it can become a liquid. For water the temperature has to be a little over zero degrees Celsius. If you were salt, sugar, or wood your melting point would be higher than water. The reverse is true if you are a gas. You need to lose some energy from your very excited gas atoms. The easy answer is to lower the surrounding temperature. When the temperature drops, energy will be sucked out of your gas atoms. When you reach the temperature of the condensation point, you become a liquid. Finally, you're a gas. You say, "Hamm. I'd like to become plasma. They are too cool!" You're already halfway there being a gas. You still need to tear off a bunch of electrons from your atoms. Eventually you'll have bunches of positively and negatively charged particles in almost equal concentrations. When the ions are in equal amounts, the charge of the entire plasma is close to neutral. (A whole bunch of positive particles will cancel out the charge of an equal bunch of negatively charged particles) Plasma can be made from a gas if a lot of energy is pushed inside. All of this extra energy makes the neutral atoms break apart into positively and negatively charged ions and free electrons. They wind up in a big gaseous ball.

4.4 Lesson 5: Physical and Chemical Changes

During this session, you will have an opportunity to build understanding to help you:

- Refine and extend the particle model to develop an atomic model of matter, and become familiar with some of the history of the evolution of this model.
- Recognize that chemical changes alter particles by rearranging their component atoms into different combinations.
- Recognize that matter is not created or destroyed during chemical changes.
- Recognize that the total number of atoms of each element is conserved during chemical changes.

It is important to understand the difference between chemical and physical changes. The two types are based on studying chemical reactions and states of matter. We admit that some changes are obvious, but there are some basic ideas you can use. Physical changes are about energy and states of matter. Chemical changes happen on a molecular level.

4.5 Lesson 6: Physical and Chemical Properties (Nano particles)

The properties of nano particles depend on their shape, size, surface characteristics and inner structure. They can change in the presence of certain chemicals. The transition from micro particles to nano particles can lead to a number of changes in physical properties. Two of the major factors in this are the increase in the ratio of surface area to volume, and the size of the particle moving into the realm where quantum effects predominate.

Ask students what are the chemical and physical properties of the Nano Sunscreen.

4.6 Lesson 7: Nano Applications - Sunscreen

Sunscreens are designed to protect against sunburn (UVB rays) and generally provide little protection against UVA rays. They come in two forms:

Chemical Sunscreens contain chemicals such as benzophenone or oxybenzone as the active ingredient. They prevent sunburn by absorbing the ultraviolet (UVB) rays.

Physical Sunscreens contain inert minerals such as titanium dioxide, zinc oxide, or talc and work by reflecting the ultraviolet (UVA and UVB) rays away from the skin.

A sunscreen with a SPF of 15 filters out approximately 94% of the UVB rays. One with a SPF of 30 filters out 97%. The SPF applies for UVB rays only. The protection provided against UVA rays in chemical sunscreens is about 10% of the UVB rating.

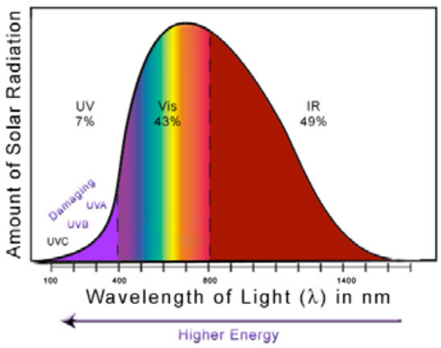

Figure2. The Sun's Radiation Spectrum

Essential Questions (EQ): What essential questions will guide this unit and focus teaching and learning?

1. What are the most important factors to consider in choosing a sunscreen?
2. How do you know if a sunscreen has “nano” ingredients?
3. How do “nano” sunscreen ingredients differ from most other ingredients currently used in sunscreens?

4.7 Lesson 8: Experiment

Titanium Dioxide is a fantastic example to use to teach chemistry and nanotechnology at the same time. One of the most interesting features of this incredible photo catalyst is that it can break down almost any organic compound (mold, bacteria) it touches in the presence of UV light. Hence, it can clean itself. Here are some examples of reactions, which focus on Titanium.

Reaction of titanium with air: Titanium metal is coated with an oxide layer that usually renders it inactive. However once titanium starts to burn in air it burns with a spectacular white flame to form titanium dioxide,TiO_2(1) and titanium nitride, TiN(2). Titanium metal even burns in pure nitrogen to form titanium nitride.

1) $Ti(s) + O_2\,(g) \longrightarrow TiO_2(s)$
2) $2Ti(s) + N_2\,(g) \longrightarrow 2TiN(s)$

Reaction of titanium with water: Titanium metal is coated with an oxide layer that usually renders it inactive. However, titanium will react with steam form the dioxide, titanium (IV) oxide, TiO2, and hydrogen, H_2 (3).

3) $Ti(s) + 2H_2O\,(g) \longrightarrow TiO_2(s) + 2H_2\,(g)$

Reaction of titanium with the halogens: Titanium does react with the halogens upon warming to form titanium (IV) halides. The reaction with fluorine requires heating to 200°C.

The actual process and reactions for making nano particles of titanium dioxide is a bit complicated, but learning the general process is more important. The great thing about the nano titanium is its high surface area. It is this high surface area that allows the chemical to react faster. This, of course, is very important if you are creating a nano sensor to detect a chemical agent. In the event of a disaster, you want to be able to detect and identify the toxin quickly.

1) How many different active ingredients did most of the sunscreens have?
2) What were the most common active sunscreen ingredients you saw? Are these organic or inorganic ingredients?

3) Did any of the sunscreens you looked at have active ingredients that were very different from the rest? If so, what were they?

4) Were you able to find a sunscreen with inorganic ingredients in it? If so, which one(s) contained them?

5) How many of your sunscreens claimed to have UVA protection? UVB protection? Broadband protection?

6) Why do you think that many sunscreens have more than one active ingredient? Why can't they just put in more of the "best" one?

7) You have just looked at a sample of the different chemicals you are putting on your skin when you use sunscreen. Does this raise any health concerns for you? If so, what are some of the things you might be concerned about and why?

8) Where could you go to find out more information about possible health concerns?

4.8 Lesson 9: Assessment

National Assessment Program Science Literacy (2006):

The five elements of scientific literacy, including concepts and processes include:

1.Demonstrating understanding of scientific concepts,
2.Recognizing scientifically investigable questions,
3.Identifying evidence needed in a scientific investigation
4.Drawing or evaluating conclusions, and
5.Communicating valid conclusions.

The following criteria may be included to assess students' PBL learning process:

5.1. Formulating or identifying investigable questions and hypotheses, planning, investigations and collecting evidence: This process domain includes: posing questions or hypotheses for investigation or recognizing scientifically investigable questions; planning investigations by identifying variables and devising procedures where variables are controlled; gathering evidence through measurement and observation; and making records of data in the form of descriptions, drawings, tables and graphs using a range of information and communication technologies.

5.2. Interpreting evidence and drawing conclusions, critiquing the trustworthiness of evidence and claims made by others, and communicating findings: This process domain includes: identifying, describing and explaining the patterns and relationships between variables in scientific data; drawing conclusions that are evidence-based and related to the questions or hypotheses posed; critiquing the trustworthiness of evidence and claims made by others; and, communicating findings using a range of scientific genres and information and communication technologies.

5.3. Using science understandings for describing and explaining natural phenomena, making sense of reports about phenomena, and for decision making. This process includes demonstrating conceptual understandings by being able to: describe, explain and make sense of natural phenomena; understand and interpret reports related to scientific matters; and, make decisions about scientific matters in students' own lives which may involve some consideration of social, environmental and economic costs and benefits.

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