Effect of Nanotechnology Instructions on Senior High School Students

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Abstract

In this research, we cooperate with senior high school teachers in Taiwan, and design senior high school nanotechnology curriculum to understand the model of senior high school nanotechnology curriculum in Taiwan. Senior high school teachers teach 503 senior high school students nanotechnology curriculum, and use "Nanotechnology problem situation questionnaire" to measurement their learning. So, we not only know how students obtain these nanotechnology concepts, but also can increase the number of nanotechnology talented person.

The results showed: 1. High school nanotechnology curriculum tends to explore the introduction and principle of technology product in daily life and high school teachers can use science curriculum base on their teaching, for example: Senior high school chemistry level 1 "Material in daily life" extend it to Ti-tech photocatalyst tile product we use, and inquire into it's titanium dioxide (TiO_2) material which will produce electron and electron hole after illuminated, then generates reactive hydroxyl radicals (OH^-), peroxynitrite root Radical (HO_2^-) and superoxide ion radicals (O^{2-}) when react with water and oxygen. These free radicals have the ability to decomposed organic compounds.

2. We obtain 453 valid nanotechnology problem situation questionnaires; questionnaire's recovery is 90.1%. After analysis, we found 20.31% of high school students (around 92 students) can answer the context they learn, but the concept about nano-science is incomplete; students can only tell simple nano-science principle, for example: TiO_2 illuminated reaction can generates free radicals and do sterilization.

3. Collecting all kinds of students' answers, we can analyze their alternative conceptions to compile high school nanotechnology conception diagnostic test, which can do a comprehensive test and use it as designing nano-science curriculum reference documents, and help them to learn more information about nanotechnology.

Keyword: High school nanotechnology curriculum, Nanotechnology problem situation questionnaire, Nanotechnology conception diagnostic test

1. Introduction

1.1 Rationale and Importance of this study

Nano vitally interrelate with our daily life, and “Nanotechnology” is the power of new industrial in 21th century which gives impetus to county industrial and competitive. Thus, education of knowing nanotechnology knowledge is a pressing matter of the moment. In Taiwan, the government has promoted “National Science and Technology Program for Nanoscience and Nanotechnology” around six years and still continuing; expect it become the main program of nanotechnology in Taiwan. “Nanotechnology Human Resource Development (NHRD) Program” is a program under the main program of “National Science and Technology Program for Nanoscience and Nanotechnology”. In NHRD program, the aim is to culturist a population as followed: (1) Leadership or implementation of nanotechnology; (2) the cognitive potential of nanotechnology, and become the manpower of industry and commercialization (Ministry of Education, 2009). The government planned to extend the knowledge of “nanotechnology” down to K-12 grades education, and wish that the impetus to nanotechnology curriculum in senior high school in Taiwan can speed up the nanotechnology literacy of senior high school student, and promote the development of nanotechnology industry (Lu, Chang, & Sung, 2010).

In Taiwan, the high school nanotechnology curriculum outlines only introduce basic and little information about nanotechnology which can’t conjunct with the original teaching materials (Lu, et al., 2010). Most of the high school teachers only hear about some nanotechnology concept terms, but not knowing the definition about it, and have doubts about the meanings, character and function of article (Chen, & Chen, 2006). Our goal is to educate the population and pass on the qualified people to meet the needs of the country. Lu and Sung (2010) completed the nanotechnology expert concepts map of high school, and transformed expert concepts map into declarative knowledge statement, and developed nanotechnology problem situation questionnaire. Using these high school nanotechnology expert concepts map, information of the declarative knowledge statement, can develop high school nanotechnology curriculum, as an extension of high school student’s teaching materials. Also we can use the nanotechnology problem situation questionnaire to examine the effectiveness of their learning, and refine high school nanotechnology curriculum in the future. And cultivate more nanotechnology talents, and develop more products of nanotechnology.

1.2 Research Objective

In this research, we cooperate with high school teachers to design a “high school nanotechnology curriculum”, and then make an experimental teaching. After the teaching, we use “nanotechnology problem situation questionnaire” to examine what high school student have had learn in this lesson, and supply the data to NHRD program and high school teachers for reference.

In the research, we inquire into 2 questions: First, How to design a “high school nanotechnology curriculum” and make the experimental teaching? Second, which level has high school student’s conceptual development of nanotechnology?

2. Literature Review

2.1 Nanotechnology

Nanometer (nm) is the hottest noun in the 21 century. A nanometer which we can’t see with

eyes and touch with hands equals to billionth of a meter, and can see it only under high resolution microscopy techniques. There is a lot of nano phenomena exist in nature, like nano magnetic navigation, photonic crystals, moth eye effect and gecko effect etc. The most famous is the "Lotus effect"; when water droplets drop on the lotus leaf, instead of spread out the droplets, it gathers together. The secret of why lotus leaf surface can gather the droplets is because the surface of lotus leaf has nano composition villus on it which makes the contact angle between water and leaf greater than 120 degrees. Therefore, when the leaf tilts a little, the droplets will roll away from the leaf surface, and bring dirty dust away (Su, 2003). In addition, there is a lot of nanotechnology product, for example, target drugs for cancer therapy is using gold nanoparticles to target organs, and then kill the cancer cell to attain the effect of therapy with heat treatment (Xue, Lu, Wu, & Zeng, 2008).

2.2 Nanotechnology and the national science teaching standards

Table 1 Comparing various nanotechnology ideas and applications with the standards.

Nanotechnology Idea	Standard it can address
The idea of "Nano" - being small	Structure of Atoms
Nanomaterials have a high surface area (nanosensors for toxins)	Structure and properties of matter, Personal and Community Health
Synthesis of nanomaterials and support chemistry (ie. Titanium Dioxide, TiO_2)	Chemical Reactions
Shape Memory Alloys and Smart Materials	Motion and Forces, Abilities of technological design, Understanding about science and technology
Nanocrystalline Solar Cells	Conservation of Energy and increase in disorder (entropy), Interactions of energy and matter, Natural Resources
Nano-coatings resistive to bacteria and pollution	Personal and Community Health, Population Growth, Environmental Quality, Natural and human-induced hazards.
Nano-materials, such as MR (magneto-resistive) fluids in security	Science and technology in local, national and global challenges.
Richard P. Feynman's talk, "There is plenty of room at the bottom". Feynman had a vision.	Science as a human endeavor, Nature of scientific knowledge, Historical perspective.

From Bowles, K. (2004). Teaching nanotechnology in the high school curriculum: A teacher's guide

3. Methodology

3.1 Research Design

First, we engage 6 teachers that are familiar with nanotechnology teaching materials, and ask them to design the "high school nanotechnology curriculum" together, base on the "Nanotechnology and the national science teaching standards". Then, these teachers use community activities class to teach the lesson to twelve classes (503 people). After the lesson, we examine the

student with “nanotechnology problem situation questionnaire”, and sort out the answers of the entire student, analyze the percentage of their correctness conception and alternative conception.

3.2 Research Tools

In this research, we use “nanotechnology problem situation questionnaire” made by Lu and Sung (2010) to examine the high school students learning on nanotechnology conception, which contained 17 proposition situations. First, we ask students to read the “proposition situation”, and then answer one to three open-ended questions.

3.3 Data Collection and Analysis

3.3.1 Qualitative data：Analysis how high school teachers make high school nanotechnology curriculum design, then researcher observe in class to collect and analysis how teachers guide students to learn nanotechnology and sum up the science conception of nanotechnology.

3.3.2 Quantitative data：Collect answer from “nanotechnology problem situation questionnaire”, then classify the answer and analysis the frequency of their answer and verify it to the qualitative information.

4. Results

4.1 High school teacher’s nanotechnology curriculum design

High school teachers introduce nanotechnology products of daily life to students, and then extend the nanotechnology conception from science teaching materials which mention in some science text book. In the end, students sum up what they learn and put these nanotechnology products’s science concept or principle in order. Table 2 shows the extend science teaching materials from the original high school science lesson, and compare with the high school nanotechnology curriculum design.

Table 2 High school science extended lesson and nanotechnology curriculum design exposition

Nanotechnology Products	High school science extended lesson	Science concept or principle exposition
1. Nano-tech Photocatalyst tile	Chemicals I, II: Materials in daily life 5-3 Nano-tech materials	Nano-tech Photocatalyst tile is made by photocatalyst TiO_2, produce electron and electron holes, which will react with water and oxygen and produce OH radical, peroxy radicals and superoxide radicals roots, after lighting. These radicals are ability to break down organic compounds and cause microbial decomposition to achieve antibacterial function.
2. Nano-vehicle glass spray	Physical III, IV: Surface tension 11-4 Contact angle	Nano-vehicle glass sprays made by using hydrophobic principle of lotus effect and are able to resistance to stains and drainage and let water and dust can not mount up on it.
3. Nano-target drugs	Chemicals I, II: Chemical batteries 4-4 Redox reaction	After nano-pharmaceutical, which carries target drugs, surface functional groups magnetized, nano-target drugs will follow the principle of nuclear magnetic resonance and adsorb

		to cancer tissues (which have Fe_3O_2) and have medical effects.
4. Nano-disk	Physical V, VI： Light wave 3-2 Diffraction and double-slit interfere experiment	Nano-disk uses the gap structure to store information. Using quarter wavelength groove and tower of height to produce optical interference phenomena to read data. The gap structure size is nanometer level and increases the density of recorded bits.
5. Nano-sport shirt	Chemicals I, II: Materials in daily life 5-2 Clothing materials and chemistry	Clothing contains nano-holes that can exude perspiration and ventilating, often made into waterproof nano-sport shirt.

From table 2, we can find that high school teachers wish to bring out the nanotechnology science conception from science teaching materials that relative to the ordinary lesson or extend from teaching materials, for example: Talking about surface tension's contact angle, teachers let high schools students to measure the contact angle of lotus microvilli and water droplets. Students found out the angles are greater than 140 degrees, which can improve the water droplets are arising by microvilli and emerge from hydrophobic. So, they observe water and dirt can't stick on it and are able to resistance to stains and drainage.

4.2 High school student's nanotechnology-related conception development

Researchers gather students' nanotechnology problem situation questionnaire answers and analysis the correctness, alternative conception and the frequency of the alternative conception, which arrange as table 3.

Table 3 Nanotechnology problem situation questionnaire answers classify and analysis

Nanotechnology problem situation questionnaire	Main alternative conception "Guessing pattern" (Percentage, Person)	Alternative conception "Cognitive incorrect pattern" (Percentage, Person)	Answer correctly, but incompletely (Percentage, Person)
1. Why can TiO_2 Nano-tech Photocatalyst tile be antibacterial?	Cause the mould can't get into TiO_2 Nano-tech Photocatalyst tile, which keep the mould outside and burn to death. (28.47%, 129 people)	Anti-bacterial effect resulting because of chemical changes (25.52%, 116 people)	TiO_2 Light reaction will produce OH radical, and kill germs. (21.63%, 98 people)
2. Why can Nano-vehicle glass spray	Nano-vehicle glass spray has small gaps which made water and	Nano-vehicle glass spray can have decontamination effect	Nano-vehicle glass spray is hydrophobic (21.63%, 98 people)

resistance to stains and drainage?	dirt unable to attach. (23.39%, 106 people)	after lighting (23.39% , 106 people)	
3. Why can Nano-target drugs attack cancer cells by not harming the normal ones?	Nano-target drugs has nano-magnet (21.63%, 98 people)	Chemical properties of nano-target drugs will directly attack cancer cells (21.63%, 98 people)	Nano-target drugs are attracted to cancer organ (19.86%, 90 people)
4. What is the principle of Nano-disk reservoir saving?	Reduce the size of object, to increase the surface area of storage capacity (23.39%, 106 people)	Application of compression principles, in order to increase memory capacity (22.97%, 104 people)	Reduce the volume of stored material to increase the memory capacity (17.89%, 81 people)
5. Why can Nano-sport shirt exude perspiration and ventilating?	Nano-sport shirt has big nano-holes and can easily ventilate (28.47%, 129 people)	Nano-sport shirt can exude perspiration easily (23.39%, 106 people)	Nano-sport shirt has small nano-holes and can easily ventilate (19.86%, 90 people)

From Table 3, we can see that high school student can't express a complete answer even after that nanotechnology learning lesson, most of the can just tell some of the correct answer, which we classify it as "Cognitive incomplete pattern". Others, around 43.26~53.99%, has alternative conception, classify as "Cognitive incorrect pattern" or "Guessing pattern". "Cognitive incomplete pattern" example like: Anti-bacterial effect resulting because of chemical changes and "Guessing pattern" example like: Because the mould can't get into the TiO_2 Nano-tech Photocatalyst tile, which keep the mould outside and burn to death.

5. Conclusion

5.1 High school teacher's nanotechnology curriculum design

High school teachers used to introduce nanotechnology product we meet in daily life to students first, then explain where or which science lesson is related to it and sum up the nanotechnology product's science concept or principle in the end. High school teachers think that letting students see the function of what nanotechnology products can do, can provoke there interest, and be willing to learn, then extending curriculum from high school science, not only can review their old experiences, but also build the scaffold to guide their learning, which student can attain the inventive principles of nanotechnology products, and be able to promote and application.

5.2 High school student's nanotechnology concept development

We can find from analyzing the nanotechnology problem situation questionnaire answer that only 20.18% (91.4) high school students can answer some of the answer correctly, the other 40% to 50% has alternative conception. Interviewing high school teachers, they think nanotechnology curriculum is an informal curriculum; using community activities time to teach, students might

think it's nothing to do with year-end examination or college entrance examination, which cause the result of student did neither review or willing to strengthen the knowledge, and had shown in the result.

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