Inquire Learning Effects to Elementary School Students' Nanotechnology Instructions

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Abstract

Nanotechnology is an emerging science that involved in different fields. This research inquired elementary school students' learning effect by using quasi-experiment, expositive-teaching and experimental-teaching methods for nanotechnology in the microcosmic world. By utilized the pretest "Nanotechnology Situational Questionnaire (NSQ)", we have selected 110 fifth grade students with similar academic performance in nanotechnology knowledge from Northern Taiwan. The instruction designed 2 teaching steps. The first step had 4 class sessions, and then implemented the expositive-teaching to all the students. The main learning context was related to understand nanometer definitions, characters and fundamental concepts. The second step divided 110 students into treatment and comparison groups, each group had 3 class sessions. The treatment group implemented experimental-teaching, on the other hand, the comparison group implemented expositive-teaching by Power Points, animations and movies. After the experiment, the 2 groups completed posttest NSQ.

The results showed: 1. Two groups were no different in posttest NSQ score after the first step teaching, but after the second step teaching, the treatment group had significant higher scores than comparison group. It means that experimental-teaching method was more effective than the expositive-teaching. 2. The experimental-teaching could simulate a realistic situation, and provided abilities in a clearer communication. Students were easier to understand and able to apply the science concepts into their daily life. For the intension of investing in future talents and promoting nanotechnology education, educators must adopt the nanotechnology into formal elementary curriculum and design a series of complete teaching plan.

Keywords: Nanotechnology, Experimental-teaching, Expositive-teaching.

1.Introduction

Nanometer is a popular term in the 21 century, it is related to our daily life (Pan, 2004), nanometer phenomenon existed in natural world for a long time, the technology can be applied in many different levels and products are continuously renovating, for example, biotech, environmental industry, electrical parts, national defense, auto and aerospace all have a great development potential. Scientists predicted the microcosmic world will have a most shocking evolution. Recently in US, Japan, Europe, Korea and even China have invested large founds in the national nanometer material developments (Lee & Tang, 2006).

Apply nanometer concepts in teaching plan; school is the best place to strengthen citizens to understand nanotechnology knowledge through curriculum. We must apply a series of education plans to improve learning effects, for example, analyze teaching objectives, learners' characteristics, in order to design teaching materials, methods, practice and then evaluate final outcome (Pan, 2004).

Teaching model is essential to the effect of strategies-based instructional education (Dansereau, 1998; Fang, & Guo, 2000). The expositive-teaching is a teaching method can display a meaningful learning. Teachers organize the teaching materials and by using a systematic oral methods to teach students. Students will combine the new and old information and further reorganize into their own cognition structure (Ausubel, 1978). In contrast, the experimental-teaching is a teaching method through hand-on experience that students learn about the world and only use their past hand-on experiences to apply to the world. Good experiences were most valuable and useful. According to Dewey, an educative experience is an experience in which we make a connection between what we do to things and what happens to them or to us in consequence; the value of an experience lies in the perception of relationships or continuities among events (Deway, 1938).

Taiwanese government invested "National Nanotechnology Program (NNP)" since 2002, and developed many "nanotechnology materials", but the common knowledge of nanometer technology is still in a fundamental stage. The nanotechnology phenomenon can be applied in production, development, and usage of such technology is limited (Lu & Sung, 2010).

Student's cognitive development in elementary school belonged to concrete operational stage or formal operational stage, so they are unable to understand the microcosmic nanometer world and phenomenon that are difficult to observe in daily life. Nanotechnology concepts are hardly been seen in the elementary school curriculum in Taiwan. This study applied experimental design with "learning by doing" and "meaningful learning" theories. We apply sensual organs generated experience to connect with hand-on teaching theory. In contrast, we applied expositive-teaching methods in order to allow student's old concepts to connect with new concepts, further produced transfer learning. Finally, the study inquired the learning effect between experimental-teaching and expositive-teaching, in order to facilitate nanotechnology concept course design in the future.

2.Background

2.1 The Nanotechnology Talent Investment Program in Taiwan

The investment for science talents directed the national competitiveness (Deway, 1938). Therefore, nanotechnology, biotechnology and computer technology are the main directions of technology development in this century. The nanotechnology development and research started by Feynman in 1959. It is recognized as one of the most important industries in the 21st century (Lee & Tang, 2006). The technology development and research brought new resource development and application to current and future world. Many advanced countries also invested large resources to this field and further listed as an important national development program（Wu, 2002）.

Taiwanese government departments invested large financial resources in nanotechnology development. The first stage “National Nanotechnology Program (NNP)” started from 2002 to 2007 in Taiwan. This NNP program was designed for education and research industries, through the nanotechnology development to develop new products for using in communication, energy, medical, environmental and food industries, further improves the quality of life. (The Office of National Nanotechnology Program, 2006; Song, 2004; Lee & Tang, 2006). In the education field, by letting students understand nanotechnology and providing sufficient talents, the education department started “Nanotechnology Talent Investment Program” in 2003, for the students in kindergarten, elementary school, high school, university to post graduate studies, workforce extended training and further expanded to lifetime training. In 2004, nanotechnology materials have already appeared in textbook in the elementary school (Chen, 2004).

Currently Taiwan is in the progress of the second stage NNP, which started in 2009 for a period of 6 years (2009 - 2014), it was intended to continue the first stage in 2002 for improving technology development and competitiveness of Taiwan（Wu, 2007）.

2.2 Expositive-Teaching

According to Ausubel’s meaningful learning theory, the expositive-teaching is an efficient and effective way of organizing classroom learning. This teaching method offers the educator the most direct route for laying a foundation for higher order thinking (Ausubel, 1963). Instruction can be arranged in a sequence of five logical steps: 1. Teacher ascertain if the student already possesses relevant concepts in his or her cognitive structure. 2. Teacher provides appropriate advance organizers, which are used to anchor the new material within established cognitive structure. 3. Teacher present the new material in an organized fashion, checking to make sure the student is subsuming the new information under appropriate organizers. 4. Teacher provides sufficient practice (drill) so that the material is thoroughly learned, becoming an integrated part of the student's cognitive system. 5. Teacher guides the student through a problem solving situation that utilizes higher order thinking skills. If the teacher is successful in executing all Or these steps, then he or she will have laid a secure foundation for the student to take the next step on his or her own, namely, implementing the powers of higher order thinking in his or her life (Rogers, 1969).

2.3 Experiential-Teaching

Experiential-teaching defined by Dewey is through hand-on or sensual organs in environment to organize, observe and experience. Learning from experience by yourself might be called "natural learning". It is an education that occurs as a direct participation in the events of life (Smith, 2003). It includes learning that comes about through reflection on everyday experiences. The experiential learning is equivalent to personal change and growth, learning is facilitated when: 1. The student participates completely in the learning process and has control over its nature and direction, 2. It is primarily based upon direct confrontation with practical, social, personal or research problems. 3. Self-evaluation is the principal method of assessing progress or success (Deway, 1938).

3.Method

3.1 Experiment Design

This study used quasi-experim,

ment to analyze students' nanotechnology learning outcome between expositive-teaching and experimental-teaching. Before the experiment, we used "Nanotechnology Situational Questionnaire (NSQ)", tested 110 fifth grade students and conducted 2 steps teaching. The first step takes 4 sessions for a subtotal of 160 minutes, the teacher teaches all students about nanotechnology concepts by PowerPoint, animation, and movies. The second step separated the 110 students into 2 groups of 55 students each and labeled them "comparison group" and "treatment group". The comparison group used expositive-teaching method by the PowerPoint, animation and movies. On the other hand, the experimental group used experiment-teaching by hand-on approach. After the experiment, two groups conducted the NSQ posttest. According to the pretest, posttest data and inquired the learning effect for the two different teaching methods. The result will be applied to future nanotechnology curriculum design in Taiwan (Table 1).

Table 1 Experiment design and teaching content

Procedure	Teaching content & Practice
Before teaching	Conduct NSQ pretest
Teaching Step 1 (160 Min)	Teaching content (160 Min) : Nanometer definitions (40 Min) 、Surface effect (40 Min) 、Size effect (40 Min) 、Photonic crystals (40 Min) . Method: Instructor prepared the PowerPoint slides, animation, movies related to the nanotechnology conception
Teaching Step 2 (120 Min)	Teaching content (120 Min) : Lotus effect (40 Min) 、Carbon nanocapsule (40 Min) 、Inquire the atomic structure of Nanoparticles e and Nanotubes (40 Min) . Method: 1.Treatment group—Experimental-teaching content and action Lotus effect: Drip some water and some dust on the lotus leaf, and then observe the interaction of water and dust. Nanoparticles : Burn the bottom part of a cup and drip a drop of water into it, while moving the water drop around the cup and observe the interaction between water and carbon deposit. Inquire the atomic structure of Carbon nanocapsule and Nanotubes: Construct C20, C60, C80 and C120 atomic structures. 2.comparison group: expositive-teaching Instructor prepared the PowerPoint slides, animation, movies of the lotus effect, Carbon nanocapsule and inquire the atomic structure of Carbon nanocapsule and Nanotubes.
After teaching	Conduct NSQ posttest

3.2 Participants

We selected 110 fifth grade students from New Taipei city in Northern Taiwan. According to pretest NSQ, students were assigned to treatment and comparison groups (55 students each). The t-test of the NSQ pretest score (t=.411, p=.682) revealed no significant differences between the 2 groups. The result showed two groups are similar in academic performance (Table 2).

Table 2 Analysis two groups in the NSQ pretest scores

Instrument	Group	n	M	SD	t value	p value
NSQ Pretest	Comparison	55	12.16	3.190	.411	.682
	Treatment	55	11.87	4.164		

$^*p<.05$ $^{**}p<.01$

3.3 Research Instrument

The NSQ was created according to expert concept map, declarative knowledge statement in elementary school nanotechnology curriculum. And NSQ was designed to assess student's comprehension-ability in nanotechnology concepts that contained 12 situations, 25 questions by 4 multiple-choices.

After NSQ first draft was created, we have selected 6 elementary middle-grade students to read the NSQ first draft and modified the unclear questions and choices. Then we invited two science professors and five experienced primary school teachers to comment on the content validity of the questions. Finally, the pretest of the NSQ draft was conducted with 232 sixth grade elementary school students, who had finished learning content. The internal consistency of the NSQ was 0.80, the question difficulties were between 0.32 and 0.77, and the discrimination indicated between 0.38 and 0.71 (Table 3).

Table 3 Situation and questions of NSQ

Content	NSQ		Content	NSQ	
	Situation	Number of questions		Situation	Number of questions
Nanometer definitions	1	3	Lotus effect	8	3
Surface effect	2	3		4	1
	10	1	Nanoparticles	7	2
Size effect	3	2	Carbon nanocapsule	11	2
	5	1	Nanotubes	9	1
Photonic crystals	6	2		12	2
	9	2			

3.4 Data Gathering and Analysis

We collected data form pretest and posttest NSQ by students. By using SPSS17.0, we analyzed the learning effect of comparison and treatment groups.

4.Results

4.1 Children's learning effect in nanotechnology

Both groups in NSQ pretest and posttest scores (t=4.557, 8.842; p=.000**) displayed significant progress after experiment (Table 4).

Table 4 Analysis two groups in NSQ pretest and posttest scores

Group	Pretest (N=110)		Posttest (N=110)		t value	p value
	M	SD	M	SD		
Comparison	12.16	3.190	15.13	4.078	4.557	.000**
Treatment	11.87	4.164	18.53	2.624	8.842	.000**

*p＜.05 **p＜.01

In order to understand the learning effects of two different teaching methods, we compared the t-test of the NSQ posttest scores (Table 5).

Table 5 Two groups in the t-test of NSQ posttest scores

NSQ & Content		Comparison		Treatment		t value	p value
		M	SD	M	SD		
NSQ posttest		15.13	4.078	18.53	2.624	-5.200	.000**
Teaching content (Step 1)	Nanometer definitions	2.15	.756	2.40	.655	-1.887	.062
	Surface effect	1.91	.888	2.24	.942	-1.875	.063
	Size effect	1.16	.877	1.42	.712	-1.671	.098
	Photonic crystals	2.67	1.415	3.02	1.027	-1.465	.146
Teaching content (Step 2)	Lotus effect	3.11	1.012	3.75	.440	-4.276	.000**
	Nanoparticles Carbon Nanocapsule	2.58	1.083	3.53	.604	-5.653	.000**
	Nanotubes	1.55	.741	2.18	.641	-4.818	.000**

*p＜.05 **p＜.01

From Table 5, we had discovered the score of the treatment group was better than the comparison group, it meant the treatment group had a better learning effect.

Teaching step 1 displayed no differences in learning concepts (Nanometer definitions, Surface effect, Size effect and Photonic crystals) between the treatment and comparison group. This means that the same teacher applied the same teaching methods to the 2 different groups and results the same.

Teaching step 2 displayed significant differences in learning concepts (Lotus effect, Nanoparticles, Carbon Nanocapsule and Nanotubes) between the treatment group and comparison group. This means that the teacher applied different teaching method to the treatment group, and it had a better learning effect (t=-4.276, -5.653, -4.818, p=.00). In another word, applied experimental-teaching method is more effective than expositive-teaching method.

4.2 Analysis Student Nanotechnology Concept in Different Teaching Methods

We analyzed the 2 groups of student concept in Lotus effect, Nanoparticles, Carbon Nanocapsule and Nanotubes (Figure 1).

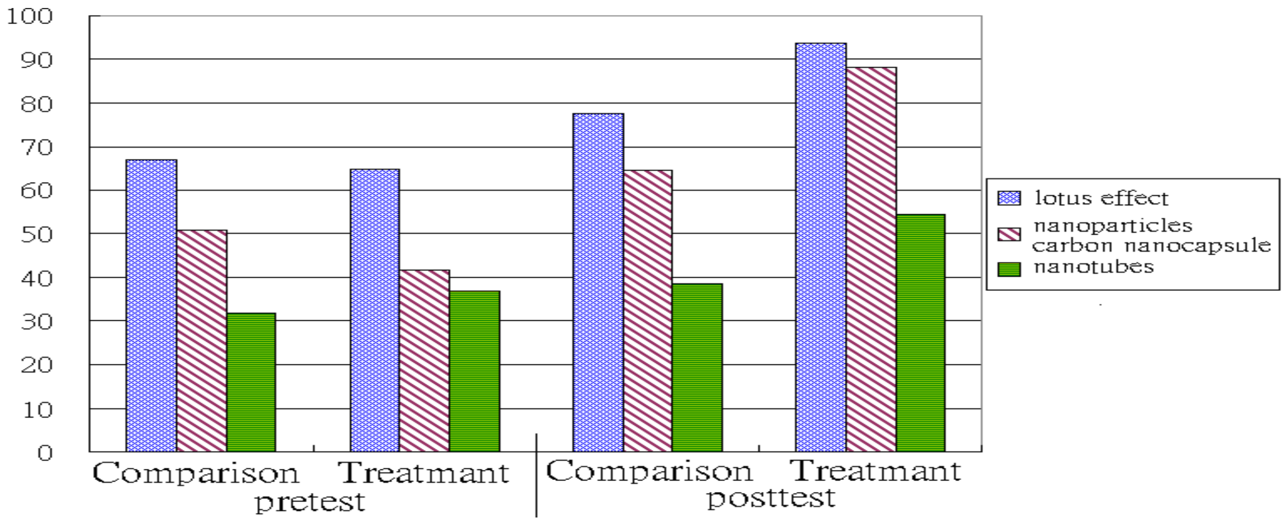

Figure 1 Comparison of two groups in nanotechnology concept learning

Figure 1 shows, the 2 groups had correct answer in *lotus effect* of 65% in NSQ pretest. All students had already learnt the appearance of the *lotus* in the 4th grade science curriculum. The expositive-teaching method in posttest comparison group, the students have had correct answer of 77.73% in *lotus effect*. The experimental-teaching method in posttest treatment group, the students have had correct answer of 93.64% in *lotus effect.* Therefore, students understood the *effect of superhydrophobicity* and *self-cleaning*, and students understood many nanotechnology products on the market that have been applying *lotus effect* for many products.

Regarding on the concepts of *Nanoparticles* and *Carbon Nanocapsul*e: In the pretest comparison group, about half of the students have already had basic knowledge. On the other hand, the pretest treatment group had 41.82% had the basic knowledge. After experiment, the comparison group and treatment group improved 13.64% and 43.36% respectively, the improvement percentage in treatment group is higher than comparison group by 23.63%; this means by using “hand-on teaching method” can intrigue students’ interest, students can have a clearer concept and further facilitates teaching for all teachers. The students’ concept of *Nanoparticle* and *Carbon Nanocapsule* for the “hand-on teaching” (treatment group) is better than “expositive teaching” (comparison group).

The concept of *Nanotubes* is less concrete than *Lotus effects*, *Nanoparticles* and *Carbon Nanocapsule*： However, the expositive teaching (comparison group) only improved 6.82% between pretest and posttest (from 31.82% to 38.64%); in contrast the experimental teaching (treatment group) improved 17.73% between pretest and posttest (from 36.82% to 54.55%). This explains students had true experience and can understand abstract concepts, hidden and hard to understand science theories better by hand-on teaching methods. Teachers are easier to communicate knowledge systematically to the students.

5. Conclusion and Recommendations

Science education have deep influence to the country and society, because nanotechnology is closely related to our daily lives, so Taiwanese government had been invested large number in human and financial resources on nanotechnology field. For improving nanotechnology industry, and allowing students to learn about nanotechnology and the application of the technology, it became a major issue in Taiwan.

The Taiwanese elementary school science education objective is: By using science curriculum and teaching design to activate students’ motivation, interest and allowing students to use the science concept in their future daily lives. Therefore, a complete teaching method needs to have a better curriculum design, by combining students’ experience and suitable teaching activities; this can further communicate science concept, and allowing students to apply into their daily lives. Nanotechnology is a cross-field emerging science, nanometer is a microscopic, amazing, hard to imagine world, although nanometer phenomenon appears in our daily lives, but in Taiwan, the elementary school curriculum hardly applying nanotechnology in the official curriculum and teaching activities.

In order to allow students to have a more complete concept of nanotechnology,

nanotechnology cognition and literacy. Educators must aware the importance of combining education with nanotechnology. For applying the nanotechnology to the whole nation's education, we must apply carefully through a complete course design and activities. If the complete course and activities can activate students' interest, then it can achieve the nanotechnology concept learning goal.

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