Promotion of popular science education of nanotechnology in Ilan by service-learning methodology

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Abstract — *Service-learning is an experience education which equally emphasizes "service" and "learning". This study focused on the promotion of a nanotech popular science education for fourth to sixth grade elementary school students, and was carried out by Ilan University undergraduate students. This design was used to train these undergraduate students to "learn" through the "services" of an integrated social service for science courses. Moreover, the elementary school could thereby gain a preliminary understanding of nanotechnology and its application. The service-learning team was directed by three teachers, including two nano-science experts and one promotion action expert. Forty undergraduate students completed 12 hours of classroom training, including an introduction to, and application of, nano-technology, experimental exercises, design of lesson plans, and presentation. The lesson plans included a quiz before and after the activities, which contain a brief introduction to nanotechnology, a lotus effect experiment, and an interactive Q&A. There were 822 students from 10 elementary schools in I-Lan participated in these activities. Most of the undergraduate students gained excellent scores, as evaluated by elementary school teachers according to their attitude, skill, and knowledge application. The post-quiz exhibited that the elementary school students made significant progress after 2 hours of promotion activity. These valuable results revealed that service-learning is a desirable education methodology, not only for promoting popular science education of nanotechnology at elementary schools, but also to allow university students to benefit from "teaching others teaching themselves" effects through learning, planning, execution, reflection, and evaluation. Nanotechnology human resource incubation and popular science education popularization were simultaneously performed through this service-learning activity.*

Index Terms — *elementary school, nanotechnology, popular science education, service-learning undergraduate students*

Introduction

Nanotechnology has become the new economic hope of the 21st century that will change the industrial structure as well as our lifestyle. Many researchers regard nanotechnology as the fourth industry revolution. Although economic depression still plagues many countries, tens of billions of US dollars per year have been invested worldwide in developing outstanding nanotechnology [1]. The National Science Foundation (NSF) estimates that by 2015 there will be a need for two million workers worldwide in the fields of nanoscience and nanotechnology. To meet the need for an educated populace that can work in the field as well as support its safe development, it is critical that universities, governments and industries support nano-education efforts [2].

Nanotechnology is the meeting ground of engineering, biology, physics, medicine, and chemistry. It is being used in, and enriches, all these fields. In turn, it is utilizing and building on key elements of these pure and applied sciences. For nanotechnology to reach its full potential to contribute to our society, it must have a workforce for research, development and manufacturing; requires the ability to attract students to nanotechnology education and training programs [3].

Beyond normal education in schools, informal science education includes museums, television, lectures, media, networks, etc., all of which are important implements to connect nano-science knowledge with the population. These popular science modes of educations offer enjoyment from learning, and facilitate effective learning by internet communication [4], image communication [5], written communication [6], lifelong learning [7], distance learning [8], and experience communication [9].

National Ilan University has recently collaborated with colleges and senior high schools in Ilan to promote the

popular science education of nanotechnology. This study is one of the activities of this project, motivated by the desire to establish a learning environment in nanotechnology and help the populace to understand nanotechnology and how it can be applied in their lives. We integrated nanotechnology experts, as well as trained teachers and students, to disseminate nanotechnology information to the Ilan populace. The dissemination approaches include a popular science lecture series, communication art series, extension education curriculum, and establishing a nanotechnology museum.

Recently, more and more universities and colleges are paying attention to service-learning, whereby the learners not only can acquire academic knowledge but also develop their social responsibility. During the training, professional knowledge of nanotechnology is important, along with the correct learning and teaching attitudes. This paper represents a brief overview of popular science education promotions for elementary school students in Ilan, carried out by Ilan University undergraduate students using integrated serve-learning methodology. It is intended to provide insights into the motivations and challenges of such a serve-learning effort.

Methodology

Integrated serve-learning is a method for teaching, learning and reflecting that combines academic classroom curriculum with meaningful service (frequently youth service) throughout the community. As a teaching methodology, it falls under the philosophy of experiential education. More specifically, it integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, encourage lifelong civic engagement, and strengthen communities for the common good [10].

For example, enthusiastic and responsible teachers design curricula related to community service to enable students to discuss their feelings in class after a community service engagement. Teachers can also establish official courses offering credits with service activities to achieve the goal of service learning; this direction of development can help to implement the real meaning of service learning [11].

Training (Preparation of service-learning)

Three enthusiastic teachers, two nano-science experts, and one promotion action expert, collaborated to design the curriculum for a seed teacher's camp for popular science education popularization in nanotechnology (Table 1). In order to become seed teachers, forty undergraduate students completed 12 hours of classroom training, including introduction and application of nano-technology, experimental exercises, design of lesson plans, and presentation.

In the nano-technology course, the category of nano-technology was introduced, including definition and development. The challenges related to classification, properties, preparation, characterization survey, and application of nano-materials were also met in this class. These course aims were developed to teach seed teachers to understand how the nano-phenomena in nature inspire human beings to develop nano-technology, and to help them comprehend the application of nano-materials and nanotechnology in our life. The undergraduate students not only learned about nanotechnology and popularization activity skills, but also collected nanotechnology-related fundamental knowledge and questions as homework activities. The databases offered them opportunity reference source to develop interactive teaching materials and a question bank for pre- and post-quizzes.

The final lesson plan included a pre-quiz, lecture, experiment, nano-school (Q&A competition), and a post-quiz, as listed in Table 2. There are 15 identical questions in the pre- and post-quizzes. Definitions of nano, nano-phenomena in nature, the concept of development history, and the application of nanotechnology were included in this quiz. The answers to each quiz were included and illustrated in the follow-up lecture, which was performed with multimedia, including PowerPoint slides and animation. The lotus effect was introduced in a DIY experiment. The smoked paper cup experiment was developed in the Taiwan National Science and Technology Program for Nanoscience and Nanotechnology (phase I). This experiment is suitable for elementary school students and beginners to learn the lotus effect in nano-science. The Q&A competition was designed as an 'edutainment' activity. Twenty questions were divided into four grades of scoring, according to level of difficulty. A minus score would be recorded for the team to select a repeated question to answer. The interactive Q&A activity was expected to liven up the atmosphere.

According to this lesson plan, seed teachers were divided into 10 groups. Each member's duty in a group included lectures, experimental DIY, competition, and administrative matters. The seed teachers had a lot of practice with their own duties and presented their promotion of nanotech's popular science education before the camp activities.

Promotion activity (service/action of service-learning)

There were 822 students from 10 elementary schools in I-Lan participating in these nanotech popular science education activities (Figure 1). Most of these elementary school students were unfamiliar with the serve-learning system and nanotechnology. Both the seed teachers and the elementary school students were shy. Therefore, it was quiet at the beginning of the camp, but they cheered up when the lotus effect experiment started. The lotus effect was designed to burn a candle to create smoke in a paper cup a quarter full of water. Incomplete burning of the candle generated carbon particles that were adsorbed on the bottom of the paper cup, forming a hydrophobic layer. The round

water drops rolling over the carbon layer, as well as the fire, attracted the students' attention. They not only learned about the lotus effect but also realized the reason why water can put out a fire by decreasing temperature. The camp activity culminated in the Q&A competition (Figure 2). The competition among the groups enhanced their sense of honor. They also gained a lot of common sense in the areas of nano-science and nanotechnology. It was little wonder that the post-quiz looked easy for the elementary school students who participated in the camp activity. They no longer felt shy after the post-quiz. Some of the seed teachers, regarded as idols, were asked to take pictures, and were requested to offer the elementary school students their MSN or E-mail addresses.

Evaluation (reflection of service-learning)—

"Reflection" is the main difference between service-learning and community service. The 40 undergraduate students wrote day records, searched and read related data, had discussions, and designed lesson plans. It was unfamiliar and hard work. Most of the undergraduate students were afraid and some of them even regretted participating in the service-learning course during training. Nevertheless, these seed teachers matured after the camp activity and learned more nano-science and experiments than previously used in their classroom. Almost all of the seed teachers got excellent scores after evaluation by elementary school teachers regarding their attitude, skills and knowledge (Table 3). The 40 undergraduate students' final reports on the service-learning course expressed the fact that they were overjoyed that they had greatly benefited from service-learning.

For the other participants, we statistically sampled the pre- and post-quizzes from 323 students from four elementary schools. The statistic results of the t-test showed that the elementary school students made significant progress after 2 hours of camp activity (Table 4). The average scores, accurate answers for 15 questions, were 8.93 (8.61 to 10.03 for different schools) and 13.33 (13.13 to 14.23 for different schools) for the pre- and post-quizzes, respectively. The post-quiz scores were 4.39 (3.43 to 5.44 for different schools) higher than those for the pre-quizzes and revealed that these students from four elementary schools made significant progress (t value was -20.35 to -9.68, $p<0.05$). Many of the elementary school students could correctly answer all of the questions after the camp activity. This result reflected that the elementary school students made great progress in relation to understanding the nano-science concepts. It also revealed the teaching effectiveness of the camp activity for nanotech popular science education combined with service-learning methodology.

Conclusion —

The undergraduate students benefited greatly and matured through their learning and service experience. Undergraduate students not only learned about nanotechnology and related skills through planning, executing and introspection, but also became active contributing citizens and community members through the service. These valuable results revealed that service-learning is a desirable education methodology, not only for promoting popular science education of nanotechnology at elementary schools but also for allowing university students to gain a "teaching others teaching themselves" effect through learning, planning, execution, reflection, and evaluation. Nanotechnology human resource incubation and popular science education popularization were simultaneously performed through this service-learning activity. The training course and camp activity were recorded on video and transmitted by the Ilan Union Cable TV Association. This promotion modulus of the popular science education of nanotechnology will continue to be performed in Ilan in order to create a superior nano-science learning environment.

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FIGURES AND TABLES

Schedule		Course	Advisers
1st day	11:10~12:00	Introduction of serve-learning and nanotechnology	Su-Der Chen
	13:10~14:00	Nano-effect and characteristics	Hui-Huang Chen
	14:10~15:00	Application of nanotechnology	Hui-Huang Chen
		Paper search and reading	Homework
2nd day	11:10~12:00	Introduction of nanotechnology camp activities and lesson plan	Hui-Huang Chen
	13:10~14:40	Exercise of nanotechnology experiment	Hui-Huang Chen
	14:40~15:00	Divide into groups and design the camp activities	Su-Der Chen
		1. Create a question for competition in camp activities 2. Design the camp activities	Homework
3rd day	11:10~12:00	Introduction of leading skill in camp activities	Wen-Hung Hsu
	13:10~14:40	Camp activity exercise	Hui-Huang Chen
	14:40~15:00	Discussion	Su-Der Chen
4th day	15:10~18:00	Demonstrate and validate camp activity	Hui-Huang Chen Wen-Hung Hsu Su-Der Chen

TABLE 1

THE RESEARCH AND STUDY COURSE OF SEED TEACHERS IN PROMOTION OF POPULAR SCIENCE EDUCATION OF NANOTECHNOLOGY

Object: 4-6th grade		Course: 100 min	
Promotion activities			
Subject	Programs (teaching/experiment steps)	Duration (min)	Materials
Did you know "nano"?	1. Divide students into groups (10 persons in one group). 2. Pre-quiz To understand how the 4-6th grade students know the nanotechnology	10	Pre-quiz paper
What is "nano"?	Introduce nanotechnology with PowerPoint and video. 1. definition of nanotechnology 2. nano-materials and nano-phenomena in nature 3. application of nanotechnology	30	Projector, computer
Nanotechnology experiment (DIY)	Exercise - the smoked paper cup (Lotus effect) 1. The bottom of the paper cup, 1/3 full of water, was smoked by a candle. Rotate the cup to facilitate the spreading and adsorption of carbon particles on the cup bottom. 2. The cup was turned upside down and a blob of water dropped on the smoked cup bottom. Move the cup slowly and observe the shape and rolling of the water blob. 3. Repeat step 2 with the other cup without smoking. 4. Compare and discuss the difference in water blob shapes and spreading between these two cups.	20	Paper cup, lighter, candle, dropper
Q & A of nano-school	1. The commodities in livelihood Ask: What nano-products appear in your home? Hint: stool, refrigerator, necktie, 2. The influence of nano-products Ask: What kind of nano-products should be developed to improve your living? Hint: Need not wash clothes, … 3. Competition (1) 16 questions about nanotechnology were divided for 4 grades according to difficulty. (2) The students voluntarily answered the question and were scored.	30	Gifts
I know what is "nano"	1. Post-quiz Same questions in pretest are examined again to inspect the efficiency in learning. 2. Score and compare with the pretest results. 3. Award prize	10	Gifts, post-quiz paper

TABLE 2

LESSON PLAN ON POPULAR SCIENCE EDUCATION OF NANOTECHNOLOGY PROMOTED IN ILAN

Moral integrity and attitude	**Excellent**	**Ordinary**	**Not good**	**Poor**
1. Attend on time	4	3	2	1
2. Remedy when unable to attend on time	4	3	2	1
3. Enthusiastic and devotional attitude	4	3	2	1
4. Active and optimistic attitude	4	3	2	1
5. Humility	4	3	2	1
Skill	**Excellent**	**Ordinary**	**Not good**	**Poor**
1. Skill in planning and organizing	4	3	2	1
2. Communication with elementary school teachers and students	4	3	2	1
3. Appropriate connect with elementary schools	4	3	2	1
4. Cooperation	4	3	2	1
Knowledge and application	**Excellent**	**Ordinary**	**Not good**	**Poor**
1. Understand the functions of elementary schools	4	3	2	1
2. Offer elementary schools some positive opinions	4	3	2	1
3. Understand and respect diverse cultures	4	3	2	1
4. Application of knowledge to service	4	3	2	1

TABLE 3

CRITICISM LIST OF STUDENT BEHAVIOR DURING SERVICE

chools	Student	Pre-quiz Score*	Post-quiz Score*	Variation	t value**
Li-ming	106	9.13±1.87	13.13±1.70	-4.00±2.02	-20.35
Kai-shun	139	8.61±1.97	13.15±1.74	-4.54±2.23	-24.03
Yu-chai	48	8.79±1.71	14.23±1.13	-5.44±1.99	-18.95
Guo-ling	30	10.03±1.77	13.47±1.46	-3.43±1.94	-9.68
Summary	323	8.94±1.92	13.33±1.66	-4.39±2.16	-36.47

* Accurate answers for 15 questions

** $p < 0.05$

TABLE 4

LEARNING EFFECT ON ELEMENTARY SCHOOL STUDENTS WHO PARTICIPATED IN POPULAR SCIENCE EDUCATION OF NANOTECHNOLOGY

Elementary schools (grade)	classes
Long-tan (5th)	2
Kai-shun (4th)	2
Li-ming (6th)	3
Guo-ling (5th, 6th)	1
Syue-jin (6th)	3
Da-li (4th, 5th, 6th)	3
Kai-shun (5th)	2
Yu-chai (6th)	2
Masai (6th)	2
Long-tan (6th)	2
Young-le (4th, 5th, 6th)	1
Kai-shun (6th)	2
Shmes (4th, 5th, 6th)	3
Li-ming (6th)	4

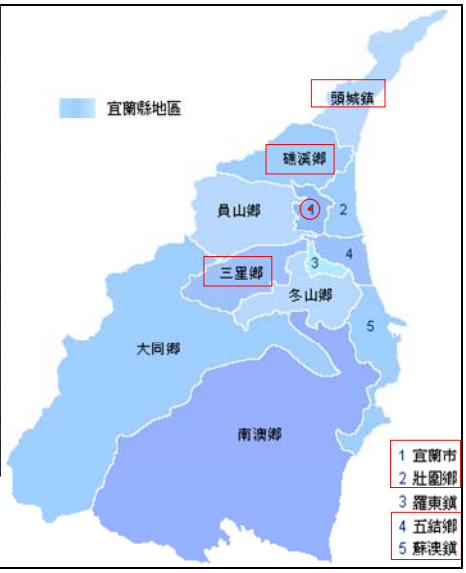
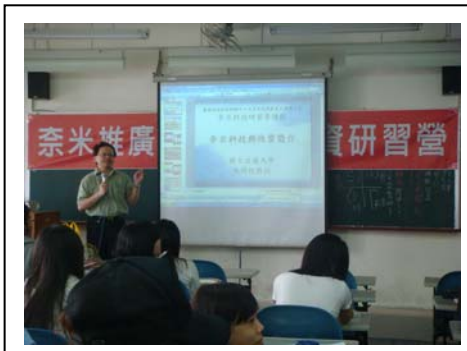


FIGURE 1

CLASSES OF ELEMENTARY SCHOOLS WHICH PARTICIPATED IN THE POPULAR SCIENCE EDUCATION OF NANOTECHNOLOGY IN ILAN.



a. Training course for undergraduate

b. Lecture in camp activity of popular science education of nanotechnology

c. Lotus effect experiment in camp activity

d. Interactive Q&A competition in camp activity

FIGURE 2

COMMENTARY ON POPULAR SCIENCE EDUCATION OF NANOTECHNOLOGY PROMOTED IN ILAN