Research Paper

Influence of "Biological Experiment for Junior High School Science Teachers" on the Skills and Ability of Students in Pre-service Teacher Education Course

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Abstract

The purposes of this research were to investigate the changes in the experimental skills and scientific ability of students as applied to a laboratory class in undergraduate course, and to examine the effects of teacher's guidance on the experimental knowledge and ability of the students. The results of this study are as follows: (1) Almost all students had observed the cells and plant tissues as well as plant cell mitosis using a microscope at the secondary level. On the other hand, many students had not experienced during school some laboratory activities such as fish dissection, detection of human blind spot, and observation of the respiratory movement of fish gills. The effects on the students of those activities that were novel were greater than those of previously experienced activities. (2) The students evaluated their own skills and ability after performing the laboratory activities. As the post-test score was significantly higher than the pre-test score for experimental skills, this laboratory class was shown to be effective in enhancing students' experimental skills. (3) The contents and evaluation method of this laboratory class were validated through the performance of the students. "Biological Experiment for Junior High School Science Teachers" may helps students enhance their experimental skills and scientific ability necessary for teaching biology at the junior high school level.

Keywords: *Curriculum, experiment and observation, pre-service teacher, science skills and ability*

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Introduction

The current junior high school curricula in Japan are based on the Course of Study revised in 1998 (Ministry for Education, Science, sports and Culture 1998). In the Course of Study for junior high school, the importance of laboratory experiments and observations in science is clearly stated. Therefore, in current Japanese science education, the emphasis is on the laboratory experiment and observation. To implement these activities in schools, it is necessary for science teachers to equip themselves with experimental skills and scientific ability in science teaching sufficiently.

There are several previous studies about the value of experimantal skills and scientific knowledge in school science; such research has focussed on the analysis of implementation of experiments at a junior high school (Togashi *et al.* 1995, Andoh 2004). Some other research has dealt with the investigation of the names of living things in biology textbooks (Mikami and Koizumi 1986, Mikami and Oka 1990). We also reported the insufficient experience of conducting experiments and observation in secondary school biology for the students in a pre-service science teacher course (Ohshika *et al.* 2005). Based on these studies it appeared that the students have limited experiences of biological experiments and observation in schools.

This research intends to find out what kinds of influence a "Biological Experiment for Junior High School Science Teachers" class can provide for students who aimed to teach science at a junior high school in order to help them enhance their experimental skills and ability necessary in the process of teaching/learning science.

Laboratory Class

"Biological Experiment for Junior High School Science Teachers" is one of our laboratory classes that are prepared for students (mostly undergraduate students) who intend to get a licence to teach science at junior high schools. In this class, the students must acquire the experimental skills and scientific ability required for biology subjects at the junior high school level.

This laboratory class is composed of 15 laboratory activities including orientation. The contents of activites are presented in Table 1. In this class, the students were able to carry out almost all areas of experiment and observation in junior high school biology. Basically, each experiment was performed as a group activity, but, microscopic observation was done individually. Each student's activities were evaluated using three criteria: attendance, attitude and reports. The report should describe the objectives, materials and methods, results, disscussion and the way of application to teaching biology at schools, and then is added a table of self evaluation. The items of self evaluation are attitude, operation skills of experimental device,

Table 1 The Content of Laboratory Class

	Title	Material
1	Orientation	
2	Observing the Animal and Plant Cells How to Use a Microscopic	Human cheek cells, Onion epidermal cells
3	Microorganisms	Microorganisms
4	Structure and Function of Angiosperm Flower	Angiosperm flowers
5	Gymnosperm Frower	Pinetree flower
6	Plant Morphology: Leaf Structures and Stomata	
7	Plant Morphology: Stem and Root	
8	Cytoplasmic Streaming	Tradescantia, Elodea
9	Plant Mitosis	Onion seedlings
10	Arthropod Morphology	Arthropods
11	Fish Dissection	Freshwater fish
12	Detection of Blind Spot and Human Sensory Reaction	Human
13	Reaction of Digestive Enzyme	Saliva, amylase
14	Fish Respiration	Killy fish
15	Photosynthesis	Elodea

style and mode of the report, results, disscussion and conclusion, and application to teaching at schools. Students were asked to do self-assesment from grade A to grade D for each item. Students were also asked to express and demonstrate their acquired biological knowledge and experimental skills and ability during carrying out each experiment.

Methods

A questionnaire was administered to 47 students who attended the "Biological Experiment for Junior High School Science Teachers" class in 2004. The questionnaire was composed of two parts; the first one included questions about the contents of the laboratory class, the second one consisted of items for a pre-test and a post-test to evaluate the experimental skills and scientific ability of the students. The items for pre- and post-test are shown in Table 2. The pre- and post-test were graded on five point scale. The scores of the pre- and post-test for the 47 students were analysed by a paired-sample *t*-test.

Results

First, we examined the personal history of the students for their biology study in senior high schools. Nineteen students (40% of the respondents) had taken some senior high schiool biology courses (IA, IB, and II) (Ministry of Education, Science, Sports and Culture 1999), and the rest had not taken any of the courses (see Table 3). We examined how often they had experienced experiments and observations in junior high school biology (see Table 4). About a half of the students had experienced performing experiments once a month and nearly a quarter of the respondents experienced performing experiments once a week.

The experiment items the students have first experienced in this laboratory class are shown in Table 5. The experiment items were classified into three categories: Plant, Animal and Microscopic Observation. As a result, many students had not done the following experiments: fish dissection, detection of blind spot and human sensory reaction

Table 2 Questionnaire Item

	Experimental knowledge
1	General biological experiment
2	Manipulation of a microscope for observation
3	Experimental apparatus and devices
4	Preparation and handling of reagents
5	Handling of biological materials
6	Saftey education in experiment
	Experimental skill
7	General biology experimental skill
8	Handling of microscope for observation
9	Experimental apparatus and devices
10	Preparation and handling of reagents
11	Handling of biological materials
12	Saftey education in experiment
13	Drawing skill for observation sketch
14	Preparation skill for making tissue section
15	Skill for animal dissection
16	Ability for making experimental report
	Biological knowledge
17	Biological knowledge at the high school level
18	Knowledge of animal (e. g., name, classification)
19	Knowledge of plant (e.g., name, classification)
20	Knowledge of animal rearing
21	Knowledge of plant cultivation
22	Knowledge of animal collection/distribution
23	Knowledge of plant collection/distribution

Table 3 Personal History on Senior High School Biology Course for Students (not required, covered in text)

	Number	Ratio (%)
Non-HS Biology	28	60
HS Biology	19	40

Table 4 Frequency of Experiment and Observation Experience in Junior High School Biology

Frequency	Number	Ratio (%)
Always	3	6
Once a week	12	24
Once a month	25	49
A few in a year	11	22
None	0	0

Table 5 First Experience Item of Experiment in the Class

Experiment item	Ratio (%)
PLANT	
Angiosperm Flower Structure	9
Gymnosperm Flower Structure	0
Leaf / Stoma	13
Root / Stem	9
Photosynthesis	4
ANIMAL	
Arthropods	21
Fish Dissection	87
Detecting Blind Spot	57
Respiration	9
Digestive Enzyme	13
MICROSCOPIC OBSERVATION	
Microorganisms	23
Cells	0
Cytoplasmic Streaming	40
Plant Mitosis	15

Table 6 Items that impressed the students most in the class

Experiment item	Ratio (%)
PLANT	
Angiosperm Flower Structure	4
Gymnosperm Flower Structure	19
Leaf / Stoma	9
Root / Stem	13
Photosynthesis	13
ANIMAL	
Arthropods	28
Fish Dissection	66
Detecting Blind Spot	64
Respiration	70
Digestive Enzyme	13
MICROSCOPIC OBSERVATION	
Microorganisms	11
Cells	0
Cytoplasmic Streaming	45
Plant Mitosis	13

time, and respiratory movement of fish gills. Nearly a half of the students had no experience in observing cytoplasmic streaming, more than a quarter of the students had not observed the arthropods in science classes. On the other hand, all students had experienced observing the cells under a microscope in junior high school or senior high school.

Table 6 shows the experiment items that the students pointed out as three most impressive activities of this laboratory class. The most impressive one was fish dissection, followed by the detection of blind spot and human sensory reaction time, and then the observation of cytoplasmic streaming. No students selected the observation of gymnosperm's flowers and cells.

Table 7-9 show the results of analysis pre- and post-test' scores by a paired-sample *t*-test. The scores for all items of experimental knowledge and skills became higher in post-test than in pre-test.

Table 7 Analysis of Pre- and Post-Test Data about Experimental Knowledge

		means	*t*	S.D.	*p*
General biological eExperiment	Post	3.72	-6.94	.97	.00
	Pre	2.75			
Manipulation of a microscope for observation	Post	4.23	-5.90	.89	.00
	Pre	3.47			
Experimental apparatus and devices	Post	3.83	-6.10	1.01	.00
	Pre	2.94			
Preparation and handling of reagents	Post	3.68	-7.32	.98	.00
	Pre	2.64			
Handling of biological materials	Post	3.61	-7.22	1.04	.00
	Pre	2.51			
Saftey precautions in experiment	Post	3.89	-9.06	1.08	.00
	Pre	2.47			

Table 8 Analysis of Pre- and Post-Test Data about Experimental Skill

		means	*t*	S.D.	*p*
General biology experimental skill	Post	3.75	-7.61	.92	.00
	Pre	2.72			
Manipulation of a microscope for observation	Post	4.19	-6.16	.90	.00
	Pre	3.38			
Experimental apparatus and device	Post	3.93	-6.04	1.08	.00
	Pre	2.98			
Preparation and handling of reagents	Post	3.60	-6.79	1.03	.00
	Pre	2.57			
Handling of biological materials	Post	3.70	-7.25	1.04	.00
	Pre	2.59			
Saftey education in experiment	Post	3.72	-8.06	1.01	.00
	Pre	2.53			
Drawing skill for obsercation sketch	Post	3.89	-6.30	1.25	.00
	Pre	2.75			
Preparation skill for making tissue section	Post	3.77	-5.72	1.23	.00
	Pre	2.75			
Skill for animal dissection	Post	3.38	-8.99	1.12	.00
	Pre	1.92			
Ability for making experimental report	Post	3.79	-7.22	1.29	.00
	Pre	2.43			

Table 9 Analysis of Pre-and Post-Test Data about Biological Knowledge

		means	*t*	S.D.	*p*
Biology knowledge in high school level	Post	3.49	-3.44	.98	.00
	Pre	3.00			
Knowledge about animal (e.g., name, classification)	Post	3.17	-4.80	.85	.00
	Pre	2.57			
Knowledge about plant (e.g., name, classification)	Post	3.11	-4.95	.83	.00
	Pre	2.51			
Knowledge about animal rearing	Post	2.78	-1.44	1.06	.16
	Pre	2.55			
Knowledge about plant cultivation	Post	2.93	-2.19	1.17	.03
	Pre	2.55			
Knowledge about animal collection/distribution	Post	2.69	-3.14	1.18	.00
	Pre	2.15			
Knowledge about plant collection/distribution	Post	2.69	-3.32	1.16	.00
	Pre	2.13			

There are also higher scores with significant differences in the items of biological knowledge except for the following two items: the knowledge about rearing laboratory animals and the knowledge about plant cultivation.

Table 10 shows the results of *t*-test between each item in the post-test. In the table, item number 2 of the experimental knowledge and item number 8 of experimental skill were significantly higher than the others. On the other hand, item number 15 of experimental skills and item number 18-23 of biological knowledge, were significantly lower than the others.

Disscussion

From the results of this study, the following confirmations were made: first, the participants of this laboratory class, had different backgrounds,

some of them had taken biology in high schools, others had not. Therefore, it is recommended that we should offer adequate program for the junior high school pre-service teacher education to students having various backgrounds in biology. And, for the frequency of experience in performing experiment and observation, many students had chances over once a month in their junior high schools. Therefore, almost all students had some skills and ability for biological experiments basically.

Regarding biological experiments in junior high school, students had more experiences in observing plants and of microscopic observation than in observing animals as shown in Table 5. Experiments or observation on animals were not performed much by the students except for on digestive enzymes. From this result, it is considered that many students had not observed many animals in their high school days, and/or many biology teachers did not use animals in their teaching of biology in laboratories. For microscopic observation, many students had experience in observing the cell structure and plant cell mitosis.

In terms of creating the most impression, many students stated the experiments that dealt with fish dissecton, detection of blind spot and human sensory reaction time, and observation of cytoplasmic streaming had the greatest impact. From these results, many students are interested in more active and dynamic activities. We noted those students have no experience in such interesting laboratory activities although they had the wish to do so. In this way, many students are expecting more experiments and observation

Tabel 10 *t*-Test between Each Questionnaire Item in Post-Test

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1		**						**							*			**	**	**	**	**	**
2	**		**	**	**	**	**		**	**	**	**	*	**	**	**	**	**	**	**	**	**	**
3		**						**							**			**	**	**	**	**	**
4		**						**	*									**	**	**	**	**	**
5		**				*		**	**									**	**	**	**	**	**
6		**			*			*		*		*			**			**	**	**	**	**	**
7		**						**							*			**	**	**	**	**	**
8	**		**	**	**	*	**		**	**	**	**	*	**	**	**	**	**	**	**	**	**	**
9		**		*	**			**		**	*				**		*	**	**	**	**	**	**
10		**				*		**	**									**	**	**	**	**	**
11		**						**	*									**	**	**	**	**	**
12		**				*		**							*			**	**	**	**	**	**
13		*						*							**		*	**	**	**	**	**	**
14		**						**							**			**	**	**	**	**	**
15	*	**	**			**	*	**	**			*	**	**		*				**	**	**	**
16		**						**							*			**	**	**	**	**	**
17		**						**	*				*					*	*	**	**	**	**
18	**	**	**	**	**	**	**	**	**	**	**	**	**	**		**	*			**	*	**	**
19	**	**	**	**	**	**	**	**	**	**	**	**	**	**		**	*			**		**	**
20	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**				
21	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*				*	*
22	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		*		
23	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		*		

* $0.05 > p > 0.01$ ** $0.01 > p$

activities in the laboratory. Thus biology teachers need to use active experiments in their teaching.

For the skills and ability of the students to perform experiments, the scores for each item showed significant difference between pre- and post-tests. The guidance of the teachers and the contents of this class are considered to have produced these results. On the other hand, the items about biological knowledge do not have larger differences than those about experimental skills.

From Table 10, all students had increased knowledge and skills for microscopic observation. Because all students might have many chances to carry out this practice in junior high schools, they had more developed knowledge and skills about microscopic studies during a class. Thus, students had developed strong confidence in how to use the microscope and how to make microscopic specimens.

On the other hand, there is a significantly lower score of skills in animal dissection than the other experimental skills. For animal dissection many students had no experience in such activity, therefore, we considered that they had not developed the skills.

There is no relationship between biological experiment and knowledge in this class. We had thought that the basic laboratory skills and biological knowledge are important in conducting biological experiments. However, many students thought that biological knowledge was not that important.

Conclusion

The importance of experimentation and observation is emphasized in the present Japanese Science Curriculum. However, the results of this study revealed that there is a problem that many students have less experienced in performing experiment and observation until high school. Therefore, the students must expose themselves to many experiments and observation activities for junior high school biology. The students can acquire more of these skills and ability in our laboratory class. As a result, pre-service students will have confidence and competency as science teachers.

From this study, we considered the neccessity of having adequate setting of items and contents of the class, and self evaluation system for report documents of the students. The results revealed that the self-evaluation system is useful for the students to confirm the necessary skills and ability on performing experiments or observation and making a report.

References

Andoh, H. (2004) A survey on the use of observation and experiment as described in lower secondary school science textbooks. *Journal of Research in Science Education* **44**(2): 95-99.

Mikami, K. and Koizumi, S. (1986) A consideration on live teaching materials presented in the course of lower secondary school. *Bulletin of the Attached Science Education Institution, Miyagi University of Education* **22**: 11-17.

Mikami, K. and Oka, K. (1990) On live teaching materials presented in the course of lower secondary school. *Bulletin of the Attached Science Education Institution, Miyagi University of Education* **26**: 27-34.

Ministry of Education, Science, Sports and Culture, Japan (1998) *Course of Study for Junior High Schools*. Printing Bureau, Ministry of Finance, Tokyo.

Ministry of Education, Science, Sports and Culture, Japan (1999) *Course of Study for Senior High Schools*. Printing Bureau, Ministry of Finance, Tokyo.

Ohshika, K. Sato, T. Muko, H. Takeshita, S. and Torigoe, K. (2005) A survey on the

experiences about biological experiment and observation and, domestication of living things in the secondary school. *Bulletin of the Graduate School of Education, Hiroshima University Part II* **53**: 455-462.

Togashi, Y., Okazaki, A., Kobori, S. Saruta, S. and Shingai, K. (1995) Implementation and Problems of 'Science' under the current Course of Study for lower secondary schools. *Journal of Research in Science Education* **36**(1): 37-44.