ISATE 2011
International Symposium on Advances in Technology Education
27 – 29 September 2011, Singapore

IN-SITU EXPERIMENT IN EARLY-STAGE ENGINEERING EDUCATION

S. Seto*, N. Tokui, S. Yamada, T. Kanmachi and Y. Kawai

Department of Electrical Engineering, Ishikawa National College of Technology
Tsubata, Kahoku, Ishikawa 929-0392, Japan

seto@ishikawa-nct.ac.jp*

Abstract

We report on a new engineering education method. It is an education method based on simple experiments performing in classroom to check and confirm basically physical laws or rules just after learning them. We call this new education method simply "*in-situ* experiment". We have been starting this new education method since 2009. We think this education method is very effective for 1st and 2nd year students in KOSEN (National College of Technology in Japan) to follow easily basically physical laws and rules taught in every class. In addition, we should point out that our education method is effective to keep their interests during class. In our electrical department, we have introduced the so-called *in-situ* experiments in various specialized subjects such as Mathematics for Electrical Engineering, Fundamentals of Electrical Engineering, Basic Electromagnetism and Basic Computer Science. From the results of the questionnaire about the *in-situ* experiment, we confirmed effectiveness of our education method; the students over 90% in classroom accept the new education method and replied that the *in-situ* experiments made the class understandable. This education method, of course, affects the traditional subjects for experiment and brings the restructuring of their contents. We are now planning to rearrange the whole curriculum in our department to fit the new education method.

Keywords: *Education, Engineering education, Technology education, Experiment, In situ experiment, Physical law*

Introduction

Kosen generally accepts junior high school graduates who have chosen one of several departments at that time in each Kousen, and educates them few specialized subjects from the 1st year to foster a practical and creative engineer. Although these specialized subjects in the early stage of Kosen's education are very important for students, some of the students lose their interests in the class and end up not to follow the class. This is a big problem not only for Kosen's education itself but also for Kosen's teachers. One reason why they cannot keep their interests during class is long lesson time of 100 minutes in Ishikawa NCT. So, they feel it to be difficult to keep their interest during class. The other main reason is that the physical laws or rules taught in class cannot be understood with a real image. On the other hand, we have conducted a lot of experiments in laboratory to ensure the physical law or rule as well as to foster a practical and creative engineer. However, the experiments for the former purpose were done later in a laboratory after learning them in classroom. For this reason, some students have forgotten the background of physical law or rule at the time when they start the experiment in a laboratory, and therefore have not deepen enough their knowledge through only the traditional experiment.

In order to resolve the above problems, we need to introduce a change of pace during class to keep their interest, especially in the early stage of Kosen's education. We propose here a new education method as our approach to resolve them. It is an active introduction of simple experiment in classroom to check and ensure physical laws and rules just after learning them. We call it "*in-situ* experiment". We introduced actively this in-situ experiment as a feature in the early-state of our engineering education since 2009. In this paper, we present what the *in situ* experiment is and how to work the *in-situ* experiments. We also discuss the effectiveness of the *in-situ* experiment through the questionnaires on the *in-situ* experiment.

Method

A schematic diagram of the *in-situ* experiment we propose is shown in Fig.1: the left in the figure is a typical scene of a traditional class, and the right one represents a scene of the in situ experiment we propose. In other words, this teaching methodology, the *in-situ* experiment is a simple experiment done by students themselves in classroom just after they learn important physical laws or rules. However, some of the experiments are demonstrated by class teacher because of using expensive equipments or its dangerousness. We expect the following advantages by doing the *in-situ* experiment.

1. The *in-situ* experiment makes physical law or rule understandable with a real image.
2. The students can confirm a physical law or rule by the *in-situ* experiment just after leaning them and

before being forgotten the meaning of them. Therefore, it is expected that they acquire solid and applicable knowledge.

3. The students can keep their interests during class by the introduction of the *in-situ* experiment. The *in-situ* experiment makes more attractive class lesson with a change of pace compared to a traditional flat lesson.

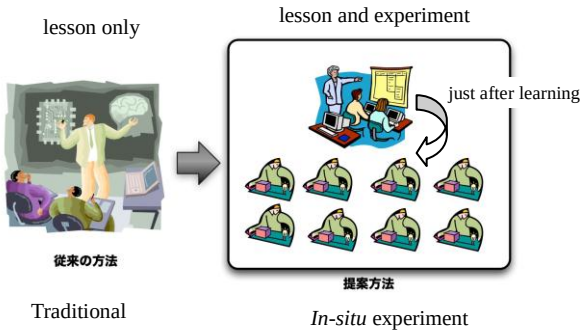

Figure 1. Schematic diagrams of traditional lesson and *in-situ* experiment we propose.

We should point out that there are two type of the *in-situ* experiment: one is the *in-situ* experiment mentioned above; another is an experiment that a teacher himself (herself) performs experiments in front of students just after teaching important physical law or rule. We call the latter experiment the so-called *in-situ* experiment too. Although we want to introduce the former type of the *in-situ* experiment into all of specialized subjects, we have turned out to adopt the latter type of the *in-situ* experiment in some of the subjects. Because the equipments used in such *in-situ* experiments are too expensive to purchase a sufficient number of identical equipments. In any case, we have purchased some new experimental equipments to introduce actively the *in-situ* experiments in specialized subjects.

We will present in the next section a few examples of the *in-situ* experiment we have performed in the 1st and 2nd year classes in the Electrical Department of Ishikawa NCT.

Results and Discussion

Figure 2 shows the snapshots of an *in-situ* experiment that each student takes part in an experiment. After learning the structure of motor, the student assembles a motor from simple materials which we can get anywhere such plastic case, clips, paper, enameled wire, drinking straw etc. Through this *in-situ* experiment, the students learn about the structure of a motor and how it works. This *in-situ* experiment was done in the class of 'Fundamentals of Electrical Engineering' for 1st year student.

Next, figure 3 is snapshots of the other type of the *in-situ* experiment done in the class of Mathematics for Electrical Engineering for 1st year. The students learn about Boolean algebra through the experiment of sequence control. This type of the *in-situ* experiment is performed by a group of three students. As you can see in the snapshots, the desks in the classroom have larger space than that in the normal classroom (see Fig.3). Our college has prepared three specially designed classrooms for the *in-situ* experiment, since some of the *in-situ* experiments need a large desk to set a relatively large experimental apparatus like denoted as the circle in Fig. 3.

Figure 2. Snapshots of the *in-situ* experiment being performed in classroom. The students fabricate a motor with simple materials during the class of Fundamentals of Electrical Engineering for 1st year student.

Figure 3. Snapshots of the *in-situ* experiment being performed in a specially designed classroom. The students learn about Boolean algebra through sequence control. The apparatus in the circle is a homemade one.

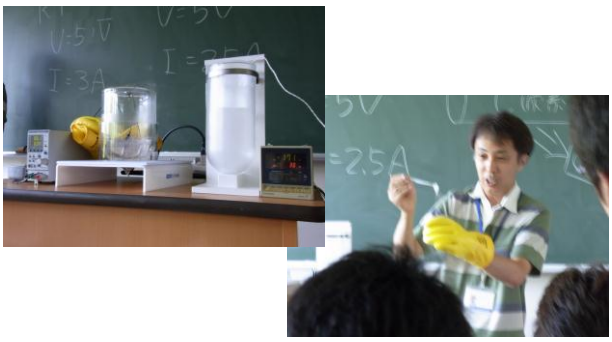

Figure 4. Snapshots of the in-situ experiment; a teacher demonstrates experiments with an attractive performance.

The last example of the *in-situ* experiment was done in the class of 'Basic Electromagnetism' for 2nd year

student. The snapshots are shown in Fig. 4. In this *in-situ* experiment, a teacher demonstrates temperature dependence of resistance on electric wires using liquid nitrogen. Because of using dangerous liquid nitrogen, the teacher conducted the experiment. This experiment is so attractive and impressive that the students lean forward in their chairs and look closely at the demonstration, as seen in Fig. 4. This type of the *in-situ* experiment, an intriguing demonstration by teacher, is also effective to keep their interests during class.

Finally, we describe questionnaire survey that was taken to confirm the effectiveness of our new education method. We present below the summary of responses to some questions for 1st year student including the classes mentioned above.

1. How do you change your interest to electrical engineering after doing the *in-situ* experiments?

Table 1. Summary of responses to question number 1

Increase interest	74 %
No change	23 %
Lose interest	3 %

2. Do you think that the *in-situ* experiment is useful for the better understanding of the specialized subject?

Table 2. Summary of responses to question number 2

Very useful	66 %
Useful	32 %
Not useful	2 %
No idea	0 %

3. Do you think that the *in-situ* experiment is needed for engineering education?

Table3. Summary of responses to question number 3

Much-needed	65 %
Needed	35 %
Unneeded	0 %
No idea	0 %

More than 70% of students in the classroom responded that their interests for electrical engineering enhanced after doing the *in-situ* experiments (see Table 1). More than 95% of students in the classroom recognized that the *in-situ* experiment was useful the better understanding of the specialized subject, as can be seen in Table 2. In addition, 100% of students thought that the *in-situ* experiment was needed for engineering education. This amazing response of question 3 convinces us that the *in-situ* experiment is highly effective for engineering education. Furthermore, we point out here that the very similar results were obtained for 2nd year student. Therefore, we can say again that the *in-situ* experiment is highly effective for the early-stage of engineering education, especially for that of Kosen's education.

Of course, we have already noticed that the *in-situ* experiment performing in classroom affects the traditional experiments that are conducted in laboratory, not in classroom. As a result, we have restructured the content of the traditional experiments. Many of the contents were so old-fashioned that we had updated them or replaced new ones. Furthermore, we are now planning to rearrange the whole curriculum in our department to fit the new education method that we call the *in-situ* experiment.

Conclusions

We have presented a new engineering education method in the early-stage of Kosen's education. This education method features the active introduction of simple experiment performing in classroom to ensure knowledge of physical laws or rules just after learning them. We call it the *in-situ* experiment. This education method was favorably received by students and resulted in the enhancement of their interests to the specialized subjects. We believe that the *in-situ* experiment is a highly effective education method to foster practical and creative engineers

Acknowledgements

We thank our colleagues, T. Fukami, Y. Morita, R. Higashi, M. Okamoto and E. Taya, for valuable discussions and comments. This project was supported by “Program for Promoting University Education” from Japan Society for the Promotion of Science. One of authors (S. Seto) was also supported in part by a Grand-in-Aid for Scientific Research C (No. 21500890) from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

Reference

Tokui, N., Kawai, Y., Taya, E & Seto, S. (2011). Introduction of *in situ* experiments in early-stage engineering education and its teaching effectiveness. *Journal of Education in the Colleges of Technology (in Japanese)* 34, pp.131-136.