Practical Report by Exercise for Integrating Science and Engineering : Proposal of Novel Open Lectures and Educational Materials

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In this report, we describe activity examples of the lecture "Trans Exercise of All Program" such as the open lecture and visiting lecture for the elementary and junior high school students, and the creation of the educational materials. "Trans Exercise of All Program" in their third year and fourth year is offered primarily for purposes of integrating fields at National Institute of Technology, Tsuyama College. The purpose of this lecture is "to acquire engineering design and teamwork skills by grasping the purpose of the theme, recognizing what needs to be prepared, utilizing one's own expertise and communicating with other specialties to solve problems that have arisen, and devising ways to solve them". The class is equivalent to "Develop multi-disciplinary ability", "Develop problem solving ability" and "Develop communication and presentation abilities". In this course, faculty member forms teams and set the theme for the exercise. Students select a theme based on their interests and participate accordingly. As the authors belong to "Electric and Electronic System", the theme of the seminar is " Electronics experience and development of electronics teaching materials". At the beginning of their third year, they participate as the assistant students in the open lectures for elementary and junior high school students. Every year, in the first week of August, open lectures such as "Let's make the LED flashing circuits" are held. By experiencing the preparation and assistance for these open lectures, students are able to propose new types of the open lectures and the visiting lectures. For example, students proposed the visiting and open lectures such as "Let's make the electronic organ" and "Let's learn the basic electronics and programming using littleBits". The goal of this course is to ultimately participate in the electrical engineering educational material planning contest hosted by the Power Academy. The participating in this contest increase the motivation of the students. Among the educational materials in the lecture created by our students, the students won excellence award in the 2nd, 3rd, 4th, and 6th contests, for example, the title of the proposed materials in the 6th contest is "Educational tool for learning biomass power generation by using the electronics". We believe that the activities described above such as the open lecture, visiting lecture, and the creation of the educational materials, have not only achieved our educational objectives but also contributed to the local community.

Keywords: *open lecture, visiting lecture, electrical engineering educational material planning contest, multi-disciplinary ability*

Introduction

In 2016, National Institute of Technology (NIT), Tsuyama College reorganized four departments, mechanical engineering, electrical and electronic engineering, electronic control engineering, and information engineering, into one department [1]. The name of the new department is the Department of Integrated Science and Technology. The Department of Integrated Science and Technology offers interdisciplinary education and integrates science as basic science with engineering for practice.

At department of integrated science and technology, NIT, Tsuyama college, in the first year, students are divided into four classes with a number of 160 students and study a variety of basic subjects. From the second year, students are assigned to a specialized field. There are four programs "Advanced Science", "Mechanical System", "Electric and Electronic System", and "Communication and Information System", in the Department of Integrated Science and Technology. Students in their second year and above not only study their respective specialized fields, but also take interdisciplinary lectures. Thus, interdisciplinary courses are necessary from the second year onwards. One such course is "Trans Exercise of All Program" offered primarily for purposes of integrating fields for third and fourth year students at NIT, Tsuyama College [2].

In this report, we present activity examples of the lecture "Trans Exercise of All Program" such as the open lecture and visiting lecture for the elementary and junior high school students, and the creation of the educational materials.

Trans Exercise of All Program

"Trans Exercise of All Program" is offered primarily for purposes of integrating fields at NIT, Tsuyama College [2]. The purpose of this lecture is "to acquire engineering design and teamwork skills by grasping the purpose of the theme, recognizing what needs to be prepared, utilizing one's own expertise and communicating with other specialties to solve problems that have arisen, and devising ways to solve them". Educational objectives of the class are "Develop multi-disciplinary ability", "Develop problem solving ability" and "Develop communication and presentation abilities".

Table 1 shows course information of trans exercise of all program I. Students will study "Trans Exercise of All Program I" in their third year and "Trans Exercise of All Program II" in their fourth year. This lecture is for one and a half years because the contents of "Trans Exercise of All Program I" is continued in the first semester of "Trans Exercise of All Program II". The pre-graduation research is studied in the second semester of "Trans Exercise of All Program II".

Students give an oral presentation at the end of the first semester of their third year as an interim presentation, a poster presentation at the end of their third year, and an oral presentation at the end of the first semester of their fourth year as a final presentation. Students also have to submit reports at each presentation. According to the rublic items of this course, "The student can use ICT, ICT tools, texts, etc. For basic information gatherring and dissemination", and the goal is "Develop communication and presentation abilities", the presentation is given to evaluate such contents.

Poster presentetaions in the third year are conducted with 3-minute presentation and 2-minute questions and answers. Students present to three assigned faculty members. In other words, students present three times. Faculty members evaluate the following three categories in the presentation.

[A] Was the poster easy to understand ?
[B] Was the purpose and content of the exercise explained ?
[C] Was the presentation time used effectively ?

Each category is rated on a scale from 0 to 5 points, for a total of 15 points.

Oral presentations in the fourth year are conducted with 4-minute presentation and 2-minute questions and answers. Three faculty members are assigned to each classroom as judges. Fuculty members evaluate the following two categories in the presentation.

[A] Was the purpose and content of the exercise explained in the presentation ?
[B] Was the Q & A session sufficient ?

Each category is rated on a scale from 0 to 5 points, for a total of 10 points.

Table 1. Course information of trans exercise of all program I

Item	Information
Course category	Specialized / Compulsory
Class format	Seminar
Credits	Academic Credit : 4
Term	Year-round
Classes per week	2

Implementation Methods

In this course, faculty member forms teams and set the theme for the exercise. Students select a theme based on their interests and participate accordingly. Typically, each instructor supervises about four students. As the authors belong to the "Electric and Electronic System", the theme of the seminar is "Electronics experience and development of electronics teaching materials". We tried to integrate the fields of the expertise by including students from various fields. Since this lecture began in 2018, we have consistently accepted students from fields other than the electric and electronic systems every year. Through exposure to programming and other areas, the course has facilitated interdisciplinary learning.

Figure 1 shows an example of a one-year schedule for third-year students in our group. In April, the placements of third-year students will be decided. After that, they will study electronic circuits and related hands-on work in our group.

At the beginning of their third year, they participate as the assistant students in the open lectures for elementary and junior high school students. Every year, in the first week of August, open lectures such as "Let's make the LED flashing circuits" [3] and "Let's make the electronic music box" are held.

Figure 2 shows the LED flashing circuits. In the open lecture, the elementary school students create the LED circuits on the breadboard. The students prepare electronic circuit components, instructions, and materials by the day of the open lecture. Table 2 shows the procedure of the open lecture. The students actively assist in this open lecture. By experiencing the preparation and assistance for these open lectures, students are able to propose new types of the open lectures and the visiting lectures.

After the open lecture in August, students propose new contents of the open lecture and the visiting lecture. The goal is to participate in the electrical engineering educational material planning contest hosted by the Power Academy, and co-sponsored by the Institute of Electrical Engineers of Japan and the Japan Electric Association. Participating in this contest increases the

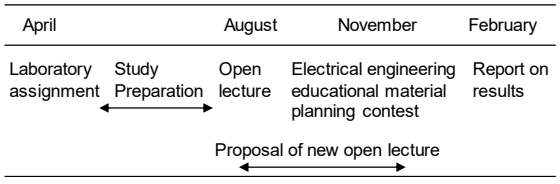


Figure 1. One-year schedule for third-year students

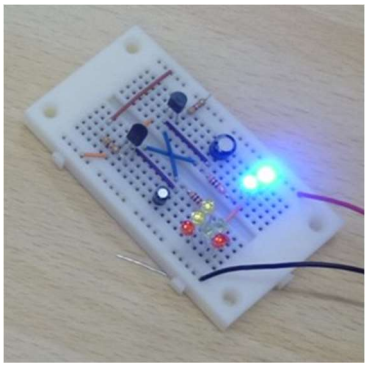


Figure 2. LED flashing circuit

Table 2. Details of open lecture

Step	Contents
1st	Important point : Explain on how to use tools (nippers, needle nose pliers)
2nd	Circuits fabrication
3rd	Experiment
4th	Discuss with assistant students
5th	Questionnaire

motivation of the students. The students submit the new lecture content related to the contest theme in November.

The open lecture and the visiting lecture are held as needed whenever requests are received. In December, presentation is held to share their outcomes, and in February, the students submit a report, as shown in Fig. 1. In addition, in the first semester of their fourth year, the students teach the newly assigned third year students about their activities.

Results

Table 3 shows the names of the novel proposed open lectures by the students. For example, students proposed the lectures with the following titles: “Let’s make the electronic timer” and “Let’s make the electronic roulette” in 2018, “Let’s make the electronic organ” and “Let’s make the mini frustrating stick” in 2020. Figure 3 shows the electronic organ, which was proposed in response to feedback from elementary school students who had previously participated in the LED flashing circuits lecture and expressed a desire to engage in more electronic circuits. Figure 4 shows the open lecture “Let’s make the electronic organ” held at the nearby elementary school in 2020.

Figure 5 shows the survey results for “Let’s make the electronic organ”. Figures 6 and 7 show the survey results for “Let’s make the electronic timer” and “Let’s make the electronic roulette”, respectively. The survey results showed that the participating elementary school students enjoyed the open lecture. They also showed that the elementary students were able to get interested in science. The survey also included a section which

Table 3. Titles of new open lecture

Year	Titles
2018	Let’s make the electronic timer
2018	Let’s make the electronic roulette
2019	Let’s learn the basic electronics and programming using littleBits
2020	Let’s make the electronic organ
2020	Let’s make mini frustrating stick

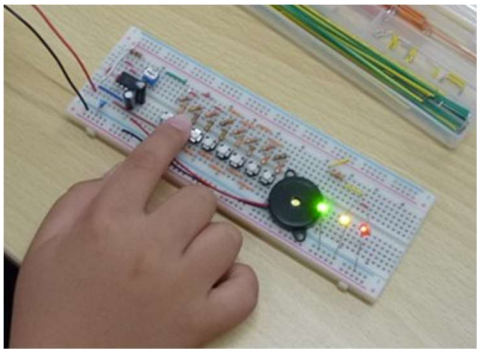


Figure 3. Electronic organ

Figure 4. Classroom of open lecture

students could write their impressions and opinions. Although only a portion of the comments are shown in Figs. 5 to 7, many of the students wrote comments such as “It was fun” and “I want to participate again”. It is clear from comments that many of the elementary school students enjoyed learning about electronic circuits and were able to get them interested.

Students proposed the open lecture titled “Let’s learn the basic electronics and programming using littleBits”. LittleBits [4],[5] is a learning material kit developed by the American company littleBits. Figure 8 shows the target shooting game fabricated with littleBits. Electronic circuits can be easily fabricated by connecting magnetic parts together. The fabricated electronic circuits can be operated using programming. It is scheduled to be held regularly in the future because this lecture is enjoyable for both children and their parents.

Table 4 shows the titles selected as excellence award in the electrical engineering educational material planning contest hosted by the Power Academy. Figure 9 shows the experiment “Let’s understand the electrical

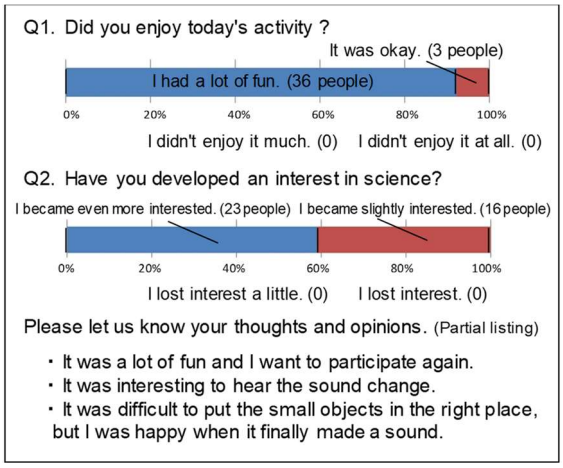


Figure 5. Survey results of "Let's make the electronic organ"

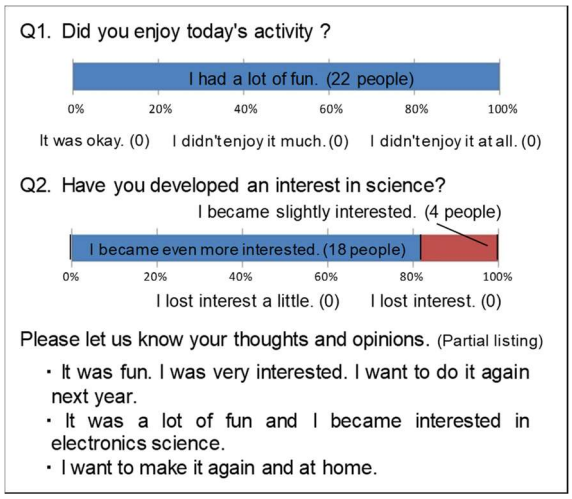


Figure 6. Survey results of "Let's make the electronic timer"

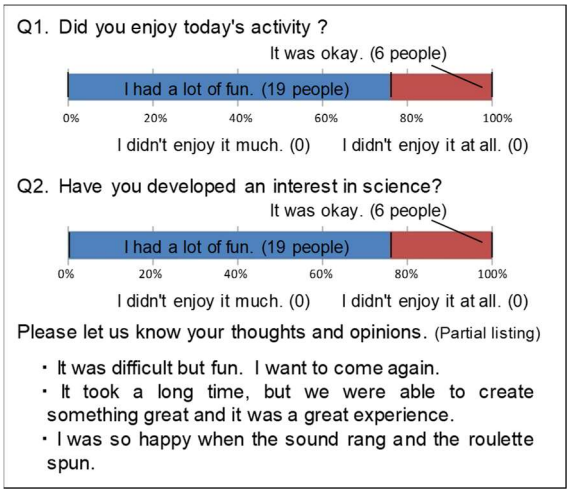


Figure 7. Survey results of "Let's make the electronic roulette"

circuits learned in junior high school by using circuit markers" in the second contest, 2020. The junior high school students can easily create the electric circuit by drawing the circuit diagram on the special paper using the circuit marker. The experiment in Fig. 9 is for learning Ohm's law.

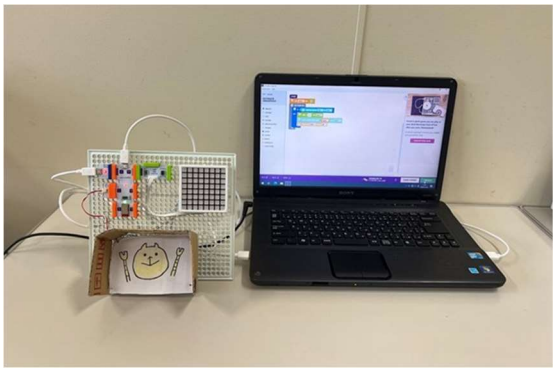


Figure 8. Target shooting game by littleBits

Figure 10 shows "Let's understand the renewable energy by using the quiz games and electronic circuit" in the third contest, 2021. Figure 10(a) shows the opening screen of the created quiz game. The quiz game incorporates elements of role-playing games, and the junior high school students can learn about the renewable energy by answering the quizzes. Figure 10(b) shows the circuit for learning about the power generating. The proposed lecture also teaches about the power generation by fabricating the electronic circuit.

Figure 11 shows the part of the experiment "Experimental educational tool for learning the difference between the direct current and alternating current by using the piezoelectric elements" in the fourth contest, 2022. By using piezoelectric speakers, the junior high school students can experiment to understand the

Table 4. Titles of the excellent award on the contest

No.	Titles
2nd	Let's understand about the electric circuits learned in junior high school by using circuit marker
3rd	Let's learn about renewable energy through quiz games and fabrication of electronic circuit
4th	Experimental teaching material for understanding the difference between direct current and alternating current using piezoelectric elements
6th	Educational tool for learning biomass power generation by using the electronics

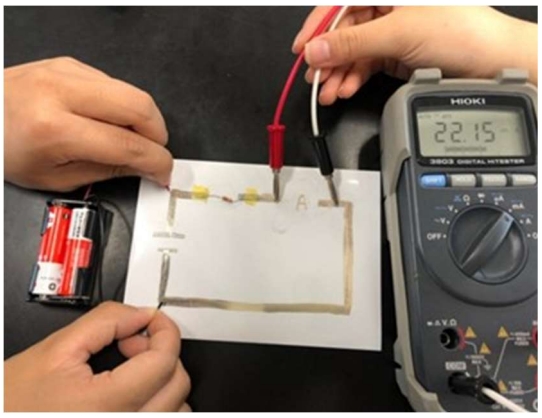
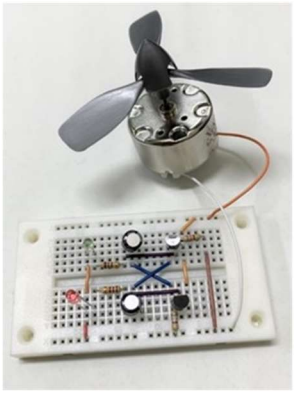


Figure 9. Experiment by using circuit markers

(a)



(b)

Figure 10. Educational materials for learning the renewable energy. (a) Opening screen of the quiz game. (b) Electronic circuit.

difference between the direct current and the alternating current.

Figure 12 shows the part of the experiment "Educational tool for learning biomass power generation by using the electronics" in the sixth contest, 2024. In this lecture, the junior high school students can learn about biomass power generation by fabricating the production using the milk plastic and LED flashing circuit.

As the above lectures were selected as the excellence award, we believe that the students were able to propose excellent open lectures. The contents of the materials selected as the award winner awards can be viewed on the Power Academy website [6].

Finally, a class questionnaire was conducted on the students who took this seminar during the final week of the seminar. The results are shown in Table 5. The questionnaire conducted at NIT, Tsuyama College has 14 items [7],[8], of which we focused on items 10, 12, and 14. This survey is scored out of 5 points, with higher scores indicating better results. The average scores from 2019 to 2022 are shown. Since a score above 4 points is considered as a good result, these results suggest that the students who took the course were satisfied with the class.

Conclusions

Activities example of the lecture "Trans Exercise of All Program" were presented in this paper. The students proposed the open lecture and visiting lecture for the elementary and junior high school students, and the

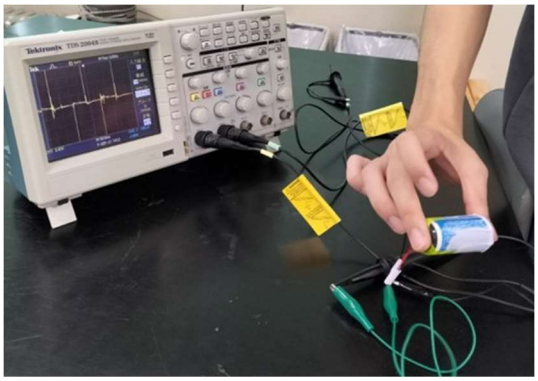


Figure 11. Experimental by using piezoelectric speakers.

Figure 12. Production using the milk plastic and LED flashing circuit.

Table 5. Results of the class questionnaire

Questions and contents	Average value from 2019 to 2022
10. Overall, would you rate this experiment / practical activity highly ?	4.468
12. Did you enthusiastically participate in the experiments and practical training ?	4.467
14. Did this experiment/practical activity make you interested in this subject ?	4.306

creation of the educational materials. Among the educational materials created by our students were selected as the excellence award in the electrical engineering educational material planning contest. We believe that the activities described above such as the open lecture, visiting lecture, and the creation of the educational materials, have not only achieved our educational objectives but also contributed to the local community.

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