# THE DESIGN AND DEVELOPMENT PROCESS OF CREATIVE PRODUCTS USING A MICROCOMPUTER

**Seiichi Watanabe, Masuo Furukawa, Takashi Kasuga**

National Institute of Technology, Nagano College

## ABSTRACT

The Department of Electrical and Electronic Engineering at the National Institute of Technology, Nagano College, has conducted creative engineering experiments using microcomputers since the fiscal year 2006. In an experiment, we designed creative products using a microcomputer in a brainstorming session. We then produced and evaluated the products in detail as a group project. Through this approach, we aim to inculcate in students the idea of systematic production and evaluation. The experiment is related to classroom implementation of the microcomputer, which has been carried out for the past 30 weeks from the final term of fourth grade to the first term of fifth grade. Since the fiscal year of 2015, it has been held for 30 weeks in the fourth grade.

In our creative engineering experiment, we first brainstormed individually, created an idea sheet, and carried out a poster tour involving all students. After the specifications were prepared by considering the opinions of other students, good ideas were selected for voting during the poster tour. Students with similar ideas gathered in groups. Based on the detailed design, we ordered electronic parts, for instance, through mail order, for performing the tasks in groups.

After completing the production, the students participated in a poster-tour-style idea contest accompanied by a demonstration; they then created and submitted a production report. Many creative products with high practicality were presented, but there were also creative products with high gaming characteristics that appeal to children. Although the degree of perfection of the work varied from group to group, the students' positive and diligent efforts were evident, and the degree of self-satisfaction was relatively high.

## KEYWORDS

Electrical and electronics engineering, microcomputer, creative engineering experiment, brainstorming, Standards: 5.

## INTRODUCTION

In recent years, engineering education has focused on engineering design, education to nurture creativity, and teamwork, which are some of the evaluation criteria used for certifying higher education institutions. In such institutions, creativity education has been increasingly introduced to meet the needs of the times (for example, Saitoh et al. (2005), Kuroda et al. (2007), Yamanaka et al. (2007), Aoki et al. (2015) and Takamura et al. (2016)).

In the Department of Electrical and Electronic Engineering at the National Institute of Technology, Nagano College, all the students had received practical training to control the running speed and direction of a model train by using a microcomputer in the latter 4 years until the fiscal year of 2005 (FY2005) under a common theme (Watanabe et al. (2009)). In our experiment, the tasks to be addressed were already determined; therefore, it was difficult for the students to demonstrate their own originality. Therefore, as an inventive educational method for nurturing creativity, in FY2006, we implemented a creative engineering experiment on a compulsory subject as an experimental theme for the engineering experiment, instead of the experiment we had previously implemented. In this experiment, we aimed to carry out a detailed design, production, and evaluation on a team basis after inventing creative products by using a microcomputer through brainstorming. In addition, by aiming to create documents necessary for executing the project in the production process, the objective of acquiring the ability to plan and conduct evaluations was met. This experiment aimed to record the experiences and workflow of students as they conceived, designed, implemented, and operated the development process by themselves.

In this experiment, microcomputer classes were held in the fourth grade, and from FY2006 to FY2014 they were held for 30 weeks from the final term of fourth grade to the first term of fifth grade. The production time per week was three hours. In the conventional practice method, the experiment was over the grade, and there was a problem with the implementation of the experiment. Because a lecture on microcomputers has been implemented in the third grade since FY2014, this experiment has been carried out for 30 weeks since FY2015 in the fourth grade. With this improvement, experiments can be conducted more efficiently.

In this paper, we describe the following items:
(1) Brainstorming and detailed design
(2) Work production and idea contest
(3) Results of the questionnaire

## BRAINSTORMING AND DETAILED DESIGN

Table 1 shows the implementation plan of the experiment. In the 15th week of the previous term, we conceived ideas, braid teams, detailed design documents, and achievement presentations by brainstorming. In the previous term, two faculty members taught the students.

As a condition of the work to be produced, six items were presented to the students. For items (3) and (4), any condition could be included:
(1) Using a microcomputer
(2) Use the microcomputer’s input/output port
(3) Using one or more sensors
(4) Using one or more actuators
(5) Exhibiting originality
(6) Production cost within 6,000 JPY (55 USD)

They used the brainstorming method to present the idea of the work that each individual wished to produce; they then described the outline and action of their work, and the parts to be used in the idea sheet (about two A4 versions). An idea presentation was held in a poster tour format for all class members so that they could share the contents of their ideas. Figure

1 shows the students in the idea presentation. A poster tour was then conducted, after a specification sheet for cost calculation had been decided upon based on the opinions of other students. The students voted for the best posters and chose four or five themes to actually produce, and those with similar ideas gathered in groups of two or three members.

Table 1. Implementation plan of the experiment (NIT, Nagano College syllabus (2017))

| Semester | Contents | Weeks |
|---|---|---|
| Previous term | Guidance, brainstorming | 1 |
| (15 weeks) | Writing an idea sheet | 1 |
| | Idea presentation (poster tour) | 1 |
| | Programming exercises (Renesas Electronics Co., R8C29) | 5 |
| | Writing a specification sheet | 2 |
| | Group organization, detailed design | 4 |
| | Achievement presentation | 1 |
| Latter term | Writing a production schedule chart and a production share table | 1 |
| (15 weeks) | Check parts | 1 |
| | Production | 5 |
| | Intermediate announcement (meeting with faculty) | 1 |
| | Production, operation check | 5 |
| | Idea contest | 1 |
| | Writing a production report | 1 |
| Total | | 30 |

The students produced detailed designs in groups for four weeks. In the detailed design document, we summarized the appearance of the work, the circuit diagram, the software flow chart, the parts list, and the reference. In the past, students presented ideas such as learning remote controls, automatic turning automobiles, electronic illumination clocks, electronic illumination thermometers, hand-held electronic games such as Othello, electronic cold storage, electronic handbells, and electronic money banks. Many creative products with high practicality were presented, but there were also creative products with high gaming characteristics that appeal to children.

Microcomputers such as R8CTiny (Renesas Electronics Co., Tokyo, Japan), PIC microcontroller (Microchip Technology Inc., Arizona, USA), and Arduino UNO (Arduino SRL, Scarmagno, Italy) were used for creative products produced by the students. In addition, devices such as temperature sensors, reed switches, hall sensors, color sensors, distance sensors, and bending sensors were also used for creative products. Circuits using microcomputers were designed on the basis of the references and datasheets of the electronic parts to be used, the details of the detailed design, and mail-order electronic parts. When using a laser diode, we took human safety into consideration.

Figure 2 shows the students taking part in the detailed design presentation. The students announced the specifics of the detailed design document using a data projector. They listened to others' opinions from the presentation and took them into consideration when completing the detailed design document. The students gradually made their idea sheets, spec sheets, and detailed design books in stages while referring to teacher guidance and the opinions of other students; thus, the contents were gradually improved.

Figure 1.  Idea presentation


Figure 2.  Detailed design presentation

## WORK PRODUCTION AND IDEA CONTEST

In the latter 15 weeks, work will be produced on a group basis and achievements will be announced at the idea contest. As in the previous term, two teachers guided the students in the latter term.

Figure 3 shows the production schedule chart, and Figure 4 presents the production share table. Based on the detailed design document, we designed a production schedule chart for a half year and a production sharing table describing the production share within the team, and we confirmed the production schedule.

The students made creative products and tested them using electronic devices such as a microcomputer development environment and oscilloscope. Some groups designed electronic substrates using computer-aided design and processed them with substrate processing machines. At first, the students were working in a peaceful atmosphere. However,

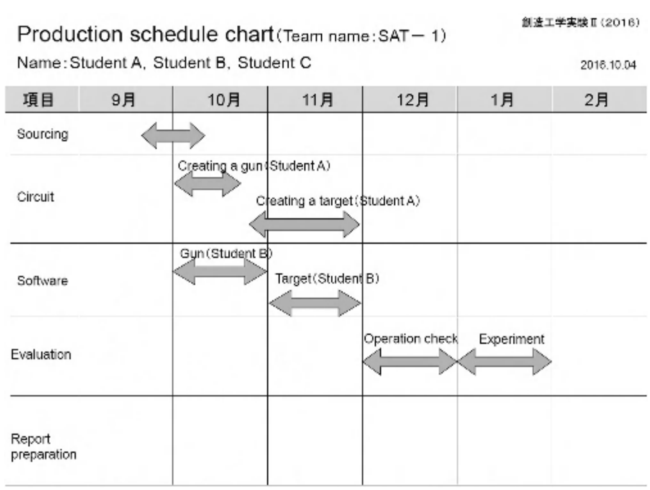



Figure 3.  Production schedule chart

Production sharing table

Team name : SAT-1
Theme : Shooting attractions（Temporary）
Name : Student B, Student A, Student C　　2016.10.04

| Member | Student B |
|---|---|
| Item 1 | 【Software: Production of guns】<br>Work contents : Production of gun software<br>Work schedule : 2016/10/18～2016/11/1 |
| Item 2 | 【Software: Production of target】<br>Work contents : Production of taget software<br>Work schedule : 2016/11/15～2016/11/22 |
| Item 3 | 【Test】<br>Work contents : Operation confirmation and correction work of the program<br>Work schedule : 2016/11/29 |
| Member | Student A |
| Item 1 | 【Test of guns and target】<br>Work contents : Examination using breadboard<br>Work schedule : 2016/10/18～2016/11/1 |
| Item 2 | 【Circuit: Production of gun】<br>Work contents : Producing gun circuit<br>Work schedule : 2016/11/8～2016/11/15 |
| Item 3 | 【Circuit: Production of target・Test】<br>Work contents : Producing target circuit, Test<br>Work schedule : 2016/11/22～2016/11/29 |
| Member | Student C |
| Item 1 | 【Testing and fabrication of light emitting part】<br>Work contents : Production of light-emitting part of gun<br>Work schedule : 2016/10/18 |
| Item 2 | 【Production of exterior parts of guns and controllers】<br>Work contents : Production of exterior parts of guns and controllers<br>Work schedule : 2016/11/1～2016/11/8 |
| Item 3 | 【Production of external exterior parts of taeget】<br>Work contents : Production of external exterior parts of taeget<br>Work schedule : 2016/11/15～2016/11/22 |
| Item 4 | 【Circuit production assistance】<br>Work contents : Circuit production assistance<br>Work schedule : 2016/11/29 |

Figure 4.  Production sharing table

as the completion deadline approached, pressure seemed to intensify. The students familiar with microcomputers, sensors, and electronic circuits were motivated to design and manufacture; however, it seemed that the students who were unfamiliar with these devices were not positively motivated. Some students concentrated excessively on familiar students and their feelings of burden.

Figure 5 shows the students during the idea contest. The students conducted an idea contest in a poster tour format that included a demonstration. They made presentations using posters that describe the specifications and features of their work. The poster was created with one A4-size manuscript using a presentation software, which was then enlarged and printed onto a B1 version with a large printer. All the participating students and several faculty members evaluated the presentations. The students rated two items, “presentation style” and “creativity,” according to five levels. The teachers evaluated four items,

(a) The contest venue (b) Students presenting

Figure 5. Appearance of the idea contest

“presentation style,” “creativity,” “completeness,” and “responses to questions,” according to five levels.

Figure 6 presents the production report. After completing the idea contest, the students submitted a production report of about 5 to 6 A4 pages to the teachers. In the report, the students described the motivation for the production, specifications of the work, details of the completed work, points devised, points requiring improvement, self-assessment (rubric format). In addition, in the details of the completed work of the report, the operation of the work produced was described using photos and text. The faculty accepted the report and gave the students grades based on the attitude of production creation, the presentation of the idea contest, and the content of the report.

## RESULTS OF THE QUESTIONNAIRE AND DISCUSSION

After the experiment, we administered a questionnaire to determine students' level of achievement of the experimental purpose, the educational effect, and the impressions of the experiment. The results of this questionnaire applied to the students who conducted the experiment in FY2016. Of the 44 students who attended the survey, 28 (collection rate 63.6%) responded. Figure 7 shows the questionnaire results. The questionnaire items and analysis results are presented as follows.

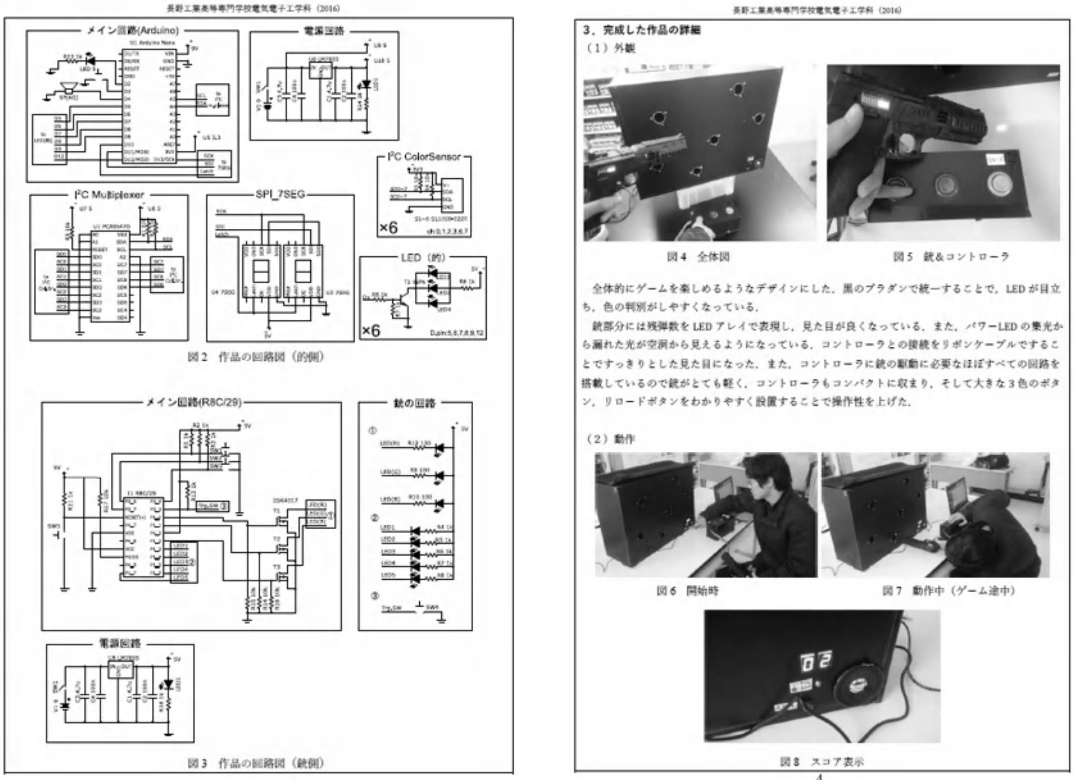


Figure 6. Production report

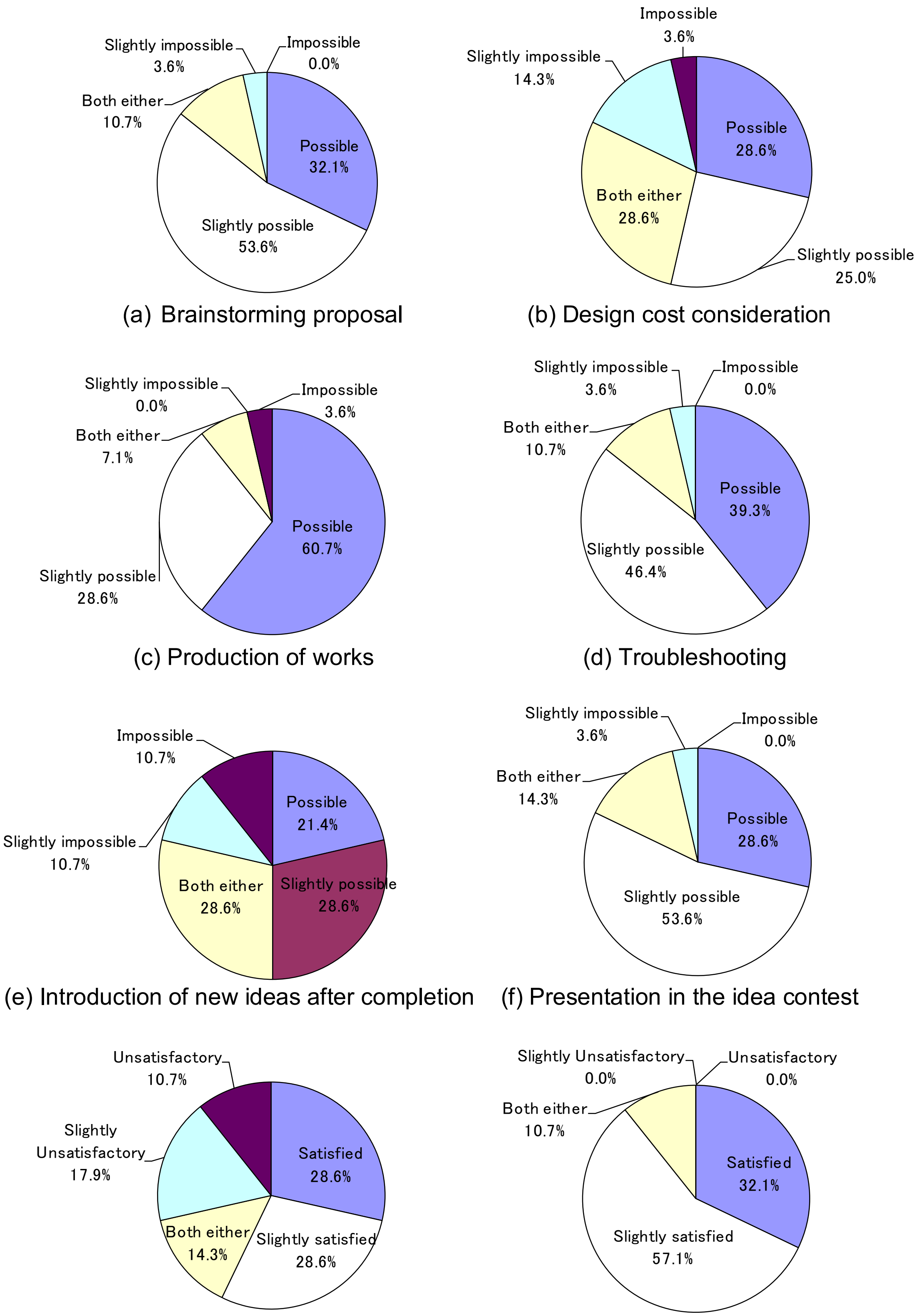
(a) Brainstorming proposal
About 85.7% of the students responded that they “invented” or “slightly invented” a product. Since advanced skills and knowledge were not required when creating a proposal, they seem to have been actively developed.

(b) Design cost consideration
Approximately 53.6% of the students responded that they were “able to design” their products or that the products were “somewhat finished.” It was assumed that mail order sales facilitated cost calculation. Some students replied that the cost increased due to the addition of parts during production.

(c) Production of works
Approximately 89.3% of the students responded that their products were “actively made” or that they were “somewhat able” to make them. Time was limited, and the students seemed to work hard.

(d) Troubleshooting
About 85.7% of the students replied that they were “able to cope positively” or “somewhat able.” Students vulnerable to circuit production and programming took time to pursue the cause and encountered trouble.

(e) Introduction of new ideas after completion
About 50.0% of the students answered “I was able to incorporate” new ideas and the product was “somewhat made.” The imposed time limit seemed to hinder the students from brushing up after completion.




(g) Work satisfaction (h) Achievement of experimental purpose

Figure 7. Questionnaire results

(f) Presentation in the idea contest
Approximately 82.2% of the students answered “I was able to present the characteristics of the work” and “I completed it to a certain extent.” Because there was limited production time, it seemed that there was no room to improve their skills after the completion of the project.

(g) Work satisfaction
About 57.2% of the students answered that they were “satisfied” or “somewhat satisfied.” The satisfaction level of the students who completed the work was high, but the satisfaction level of the students who did not finish was low.

(h) Achievement of experimental purpose
About 89.2% of the students responded that they were able to “achieve” or “somewhat achieve” the objectives described in the syllabus. Regarding the degree of accomplishment, the results were generally good, and the students could voice the particulars of their efforts.

In addition, in the free description, the students indicated the following: “Please tell us about the development environment that can be used in advance”; “Please tell me about the specifications and safety of the laser diode”; “Please increase the number of leaders”; and “I’d like you to decide which theme to produce.” From now on, we will provide students with information on specifications and user safety.

Moreover, we would like to provide students with thorough reporting and instruction schedule management methods. It is undesirable to only increase class hours and the number of teachers. In order to voluntarily increase the time students spend in trying to solve problems themselves, we hope to establish rudimentary experiments for learning the process of CDIO in lower grades to improve students’ problem-solving skills and creativity.

## CONCLUSION

In this paper, we described the details of a creative engineering experiment conducted from 2006 in the Department of Electrical and Electronic Engineering at the National Institute of Technology, Nagano College, as well as the questionnaire results. In this experiment, after inventing creative products by using a microcomputer through brainstorming, detailed designs, production, and evaluations were carried out on a team basis, and an idea contest was conducted as a summary. This experiment aimed to record the experiences and workflow of students as they conceived, designed, implemented, and operated the development process by themselves.

Based on the questionnaire results, it seems that the students actively engaged in detailed design. However, regarding the degree of accomplishment, perfection achievement was low due to an insufficient amount of production time; the same can be said for production level, which was also considered to be low.

## ACKNOWLEDGMENT

We would like to thank Editage (http://www.editage.jp) for English language editing.

## REFERENCES


Tohru Saitoh, Kazuhiko Ishikawa, Yuichi Takaku and Masashi Shimojo (2005). An Experiment Environment for System Design in Department of Electronics and Information Engineering, *Research reports of Fukui Technical College*, 39, 37-44 (in Japanese).

Takaharu Kuroda, Hiroaki Uchida and Makio Shimizu (2007). A Creative Education of Electric Engineering Experiments for the Students of Department of Mechanical Engineering, *Journal of Education in the Colleges of Technology*, 30, 19-24 (in Japanese).

Noboru Yamanaka and Yoshihiro Tachiyama (2007). New Approach of Experiment for Manufacturing by PBL – Theme Selection and Text Investigation –, *Research report of Miyakonojo National College of Technology*, 41, 93-100 (in Japanese).

H. Aoki, M. Nagai and K. Asano (2015). Graduation Research Based on Social Implementation Education, *Transactions of the 9th International Symposium on Advances in Technology Education*, 138-142.

K. Takamura, M. Iguchi, K. Ohshima and S. Funaki (2016). Approach on Project Based Learning International Institute of Technology, Asahikawa College, *Transactions of the 10th International Symposium on Advances in Technology Education*, 468-471.

Seiichi Watanabe, Masuo Furukawa, Masahiro Akiyama and Noritaka Momose (2009). Execution of Creative Engineering Experiment Using Problem Based Learning, *Proceedings of annual conference of Fundamentals and Materials Society, IEE Japan*, 91-96 (in Japanese).

National Institute of Technology, Nagano College of Japan (2017). Syllabus of "Creative Engineering Experiment", http://syllabus.nagano-nct.ac.jp/ (in Japanese).


## BIOGRAPHICAL INFORMATION

***Seiichi Watanabe***, D. Eng. and Senior Educator (Eng. and Tech.) is a Professor in the Department of Electrical and Electronic Engineering at National Institute of Technology, Nagano College, Japan. He is engaged in research on measurement engineering.

***Masuo Furukawa***, M. Eng. is a Professor in the Department of Electrical and Electronic Engineering at National Institute of Technology, Nagano College, Japan. He is engaged in research on educational engineering, welfare equipment development, embedded systems.

***Takashi Kasuga***, D. Eng. is an Associate Professor in the Department of Electrical and Electronic Engineering at National Institute of Technology, Nagano College, Japan. He is engaged in research on electromagnetic compatibility.

### *Corresponding Author*


Dr. Seiichi Watanabe
National Institute of Technology, Nagano College
716 Tokuma, Nagano-shi, Nagano 381-8550, Japan
+81-26-295-7063
watanabe@nagano-nct.ac.jp