Intelligent Science and Engineering Project-based Learning at the Graduate School of Natural Science and Technology, Gifu University

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ABSTRACT
This paper introduces the Graduate School of Engineering program at Gifu University from the aspects of engineering education and STEMA education. This program has been effective by participating in the Experimental Rocket Launching Campaign that has been held in France since 2005 at the Department of Mechanical Engineering, Gifu University. The campaign has also been introduced and implemented in the master's program on Intelligent Science and Engineering Project-Based Learning. This launching campaign is sponsored by Planète Sciences, a member of the French National Center for Space Research (CNES), for aerospace education and science education targeting young people. It is an event to encourage and stir an interest in aerospace education. By having students go through a series of processes of rocket planning, design, production, launch, result analysis, and reporting, they will gain a wealth of education, solid specialized knowledge and skills, a broad perspective, comprehensive judgment, and an excellent understanding of the topic. The purpose is to train highly specialized professionals in autonomy and internationality in addition to communication skills. In addition, by completing this process, students can develop the basics of manufacturing, project management methods, and problem-solving abilities by solving problems that occur in real-world projects as a team.

Keywords: *Project-Based learning, Experimental Rocket Launching Campaign, Planète Sciences, Project management, Graduate School of Engineering program.*

1. INTRODUCTION

Gifu University has been targeting establishment of project-based learning (PBL) and teaching to improve practical education and effects in the region. Establishing practical education has improved the practical educational effects by receiving and implementing Gifu University activation expenses for education in 2012, 2013, and 2014. The University, through the Graduate School of Engineering, has focused on the promotion of global science and engineering practices in education. This is done through the training of human resources to support innovation, and the development of cutting-edge research programs and collaboration with other universities and organization. From 2005 to 2019, Gifu has participated in the Experimental Rocket Launching Campaign held in France 13 times [1–4] and saw great success. This is the introduction of the program that has been raised to reform the educational system of the graduate school as PBL learning. This campaign is sponsored by Planète Sciences, a member of the French National Center for Space Studies (CNES), to encourage aerospace and science education for young people. Students gain a wealth of education and solid specialized knowledge by completing a series of processes of experimentation, measurement planning, design, production, launch, result analysis, and reporting through the development of experimental rockets and CanSats. The purpose is to train advanced and global professionals in autonomy and internationality in addition to skills, a broad perspective, comprehensive judgment, and excellent communication skills. In addition, by completing this process, students can learn the basics of manufacturing, the methods of project management, and problem-solving and design thinking abilities by solving

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problems that occur throughout the project as a team. In addition, as a CanSat program in collaboration with the prefectural board of education, students will be able to support experiments and learn independently through former participants as student advisors (SAs) in production classes and competitions. This program can be expected to improve, and the effect of the program will be examined.

2. BACKGROUND AND ACHIEVEMENTS OF PBL CLASSES

In the educational program of the Department of Human Information Systems Engineering (currently the Department of Mechanical Engineering, Intelligent Mechanical Engineering Course) the production of robots, which is now a feature of this department, PBL was introduced in 2004. Initially, the main purpose was to instill practical knowledge, but it was expanded in 2009 to cover aspects suitable for the development of basic abilities could be implemented while being aware of its relationship with the medium-term goals. The target theme, which initially lasted three weeks, has been expanded to five weeks, giving students more time to think and create on their own. Furthermore, by trying to improve the presentation evaluation at the end of the series of tasks and the content and environment of implementation, we cultivated communication ability, presentation ability, and ability to think and progress. Furthermore, with the intention of providing education at the graduate level, small experiments were conducted in France from 2005 to 2019 at the Department of Human Information Systems Engineering and Mechanical Engineering, the Graduate School of Engineering, and more. The program that participates in the Experimental Rocket Launching Campaign has been introduced into the graduate school education system and has been further developed into practical education and design thinking education that accompanies the reorganization of the graduate school. The overall goal is to expand the effect to a wide range of people through cooperation between technical colleges, vocational schools, and high schools, which is challenging feat.

3. EDUCATION PLAN AND METHOD

Educational plans and method for accomplishing the goals of the experimental rocket was developed in accordance with PBL as discussed below. The whole members were divided into three groups: mechanical design/manufacturing, electronic circuit design/manufacturing, and software programming. Each group consist of three to four people, depending on the total participants. The key point of this project was the cooperation of different fields of mechanical engineering, electrical engineering, and information science. The total duration for the project design and production is 15 weeks (3 months). The general schedule is as listed below.

Weeks 1–4: Studying design methods and determining specifications and experimental theme.

While graduate students with experience of M2 or above acted as SAs, students learned and understood rocket regulation, scheduled the entire project, and discussed rocket specifications.

Week 5–8: Airframe/circuit design and program creation.

Based on the determined specifications, the mechanical design and production group designed the airframe and mechanical design using composite materials, and the electronic circuit design group designed the electronic board. In addition, the program group learned the basic programs necessary for rocket operation and control and their development environment. Since the programming language learned in another lecture was also used for development, it became a place for students to practice what they learned. At this stage, the electronic board was not completed, so we used an experimental board to instill programming skills. During production, we held regular discussions and confirmed the production plan to make people aware of the actual manufacturing process. In addition, the French Planète Sciences staff gave a presentation of the project corresponding to the intermediate check in English for each group. In addition, there was also a lecture on the concepts of measurement, calibration, and mission in English by the French person in charge, Jerome, and a comment on the progress of the project. It was very useful for the students' ways of thinking.

Weeks 9–12: Assembly and production of a small experimental rocket.

The rocket body, machining, and electronic circuit were designed and or fabricated by the relevant group. By devising a harmonious design of software represented by programming and hardware with size, weight, and strength suitable for power, we were able to experience integrated design and production in a practical manner. In addition, by actually laminating and manufacturing the CFRP (fiber-reinforced plastic) rocket body, we deepened our practical understanding of the differences in processing methods from conventional materials and the differences in metals and composite materials. Figure 1, Figure 2, and Figure 3 show the designed rocket body, the designed rocket simulation, and the designed configuration rocket system, respectively.

Weeks 13–15: Checking and improving the operation of each part and launching in France

Each team discussed and consulted with each other to check and improve the operation of the rocket with functions based on the experimental theme, and to create materials such as slides in English used for presentations and explanations in France. Participants took part in the French tournament of Tarbus, by launching the developed rocket. The process involved safety and operational check of the mechanics, electronic circuits and programs, and an adaptation examination by the French tournament regulation. During this time, we also exchanged technology and culture with other teams. After the launch, the entire project was evaluated, and a report was prepared in English. In addition, by making the students themselves evaluate other teams and making them aware of the viewpoints of the evaluators, we also focused on the differences in ideas and techniques due to cultural differences. Through these projects, in addition to a wealth of education and solid specialized knowledge and skills, students gained a broad perspective, comprehensive judgment, and excellent communication skills, which are the skills of a highly specialized professional with independence and internationality.

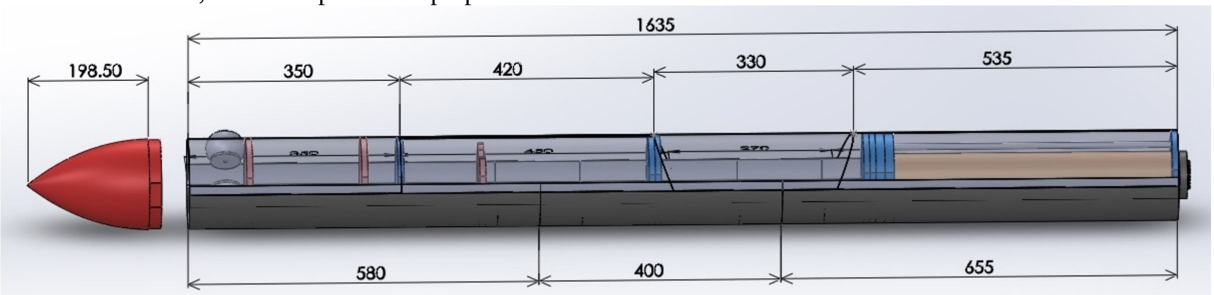

Figure 1 Designed experimental rocket body from the 2019 project.

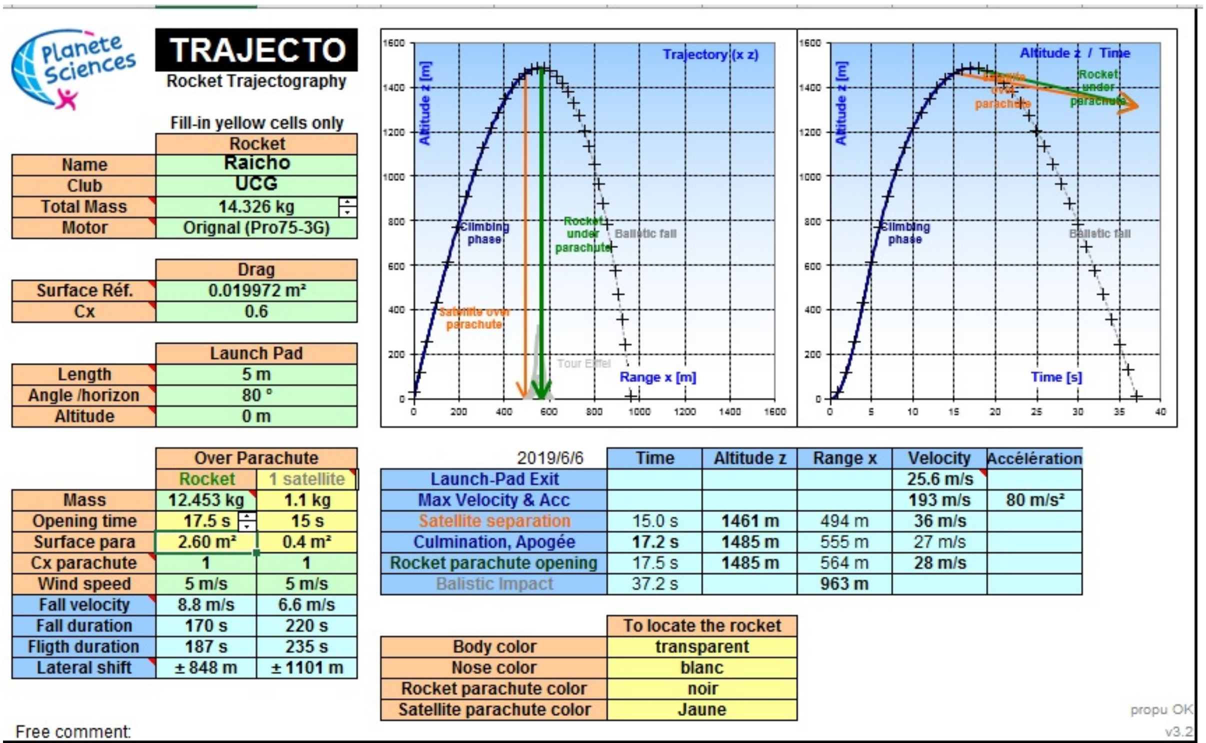

Figure 2 Simulation result of the designed rocket trajectory in 2019.

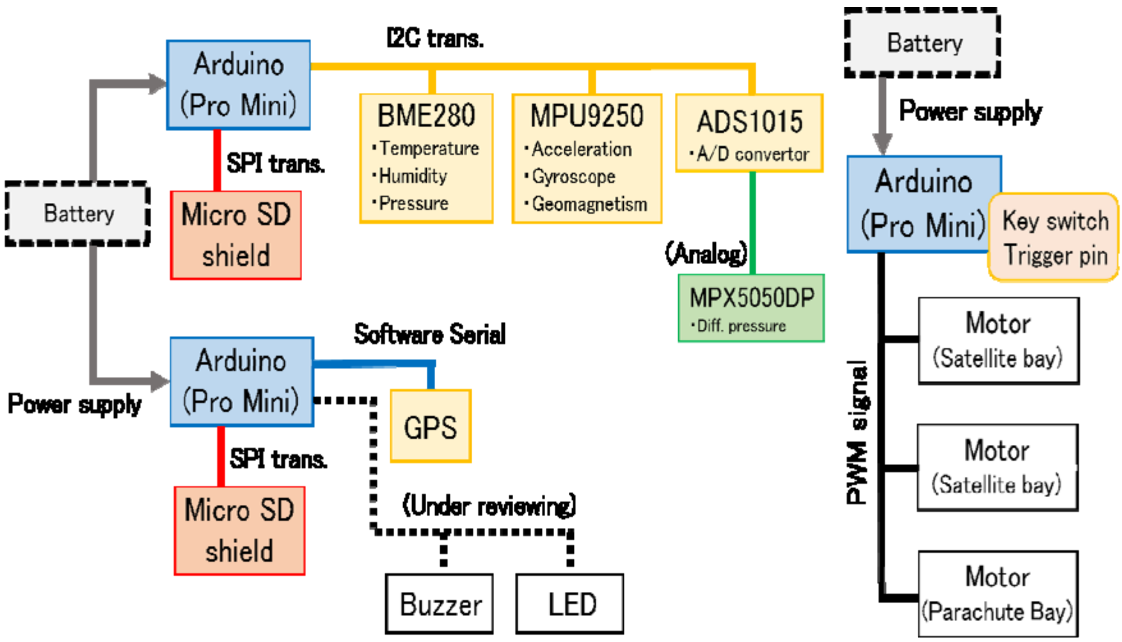

Figure 3 Configuration of the rocket system in 2019.

4. CONCLUSION

Adopted for the 2015 Gifu University Revitalization Expense (Education), with a budget of 900,000 Japanese yen, six students were able to participate in our C'Space 2019 and actually manufacture a small experimental rocket from July 23–July 30, 2019, that was showcased in Tarbus, France. The goals set for the designed and manufactured rocket were successfully cleared, and through the project of the small experimental rocket, students were able to gain manufacturing skills such as planning, scheduling, design, manufacturing, testing, launch experiment, result analysis, analysis, presentation, and reporting. Furthermore, focusing on the project as a team helped students understand the mutual relationship between leaders and followers, the importance of communication within the team, and mutual understanding by directly engaging with different cultures. It is important to explain the project in English, which is a foreign language, and to feel the difficulty of communicating with each other while at the same time interacting with people from other countries and learning about cultural differences and the world. In the future, we will consider issues based on the results of this 2019 project-based learning, and by fixing those issues, we will improve future projects. The functions and elements that students learned were required for rockets and simulated satellites were: ingenuity of how to realize something that fulfills a certain function, building things, repeated testing-improvement, patience, endurance, budget, ability, goal setting, project management, teamwork, time, money, people, risk management, and serious discussion. Students also developed the ability to think for themselves. Finally, the results of the class questionnaires from 2015–2021 are shown for reference. (The number of participants is 70).

(1) Did you find this lecture interesting?

Yes 70, to some extent 0, No 0.

(2) Did you understand this lecture?

Yes 67, to some extent 3, no 0.

(3) Was the content of the lesson clearly indicated on the syllabus?

Yes 56, to some extent 14, no 0.

(4) Were the content and procedure of this lecture appropriate?

Yes 67, to some extent 3, no 0.

(5) How many hours did you spend preparing and reviewing this course on average during the week?

The average value of 70 people was 37.3 hours/week.

(6) Comments on this lecture

・ Strength is gained.

・ It was participatory learning.

・ I'm glad I had the opportunity to make a presentation in English.

・ I'm glad I was able to make a rocket on my own.

・ It was very fulfilling.

・ I was able to make practical things.

・ I understood their problems.

・ The explanation was easy to understand.

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