

# A project-based learning task for ESL students to design and carry out an experiment without a laboratory.

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Students in an elective English-only course at the Okayama University of Science designed and carried out simple experiments as part of a project-based learning task. This task was not the main focus of the course, but was a supplement to a communication-focused English course. This study outlines how the students were given a basic introduction to academic writing and were guided through the process of designing an experiment without the use of a laboratory. Examples of student experiments and the timeline of the project are included.

岡山理科大学の英語のみで行われる選択科目において、学生は課題解決型学習の課題として簡単な実験を計画・実施した。このタスクは当該科目の主要な活動ではなく、コミュニケーションに焦点を当てた英語コースの補足として行われた。本研究は、どのように学生にアカデミックライティングの初歩的な導入を教授し、そして、どのように実験室を使用せずに実験をデザインするプロセスを指導したかについて概説している。さらに学生の実験例やプロジェクトのタイムラインについても提示している。

**Keywords:** English-only, ESL (English as a Second Language), project-based learning, research, Communicative English, 発信英語

## Introduction

Most of the students at Okayama University of Science in Japan are majoring in science or engineering subjects. The students who entered the university before 2021 are required to obtain 10 credits from foreign language courses, including 2 credits from Communicative English (発信英語 I and II) and 4 credits from Integrated English (総合英語 I - IV). The remaining 4 credits can be obtained from elective courses in English or other foreign languages. Two of the available elective courses are a continuation of Communicative English (発信英語 III and IV). The Communicative English courses consist of English-only classes taught by native speakers of English. The students who choose to take Communicative English III and IV generally have intermediate English skills (average VELC score of 480, which is equivalent to a TOEIC score of around 430). Since many of the students at the university will go on to work in the fields of science and engineering, an experiment project was used as part of the Communicative English IV course to help the students become familiar with words and grammar that are used when talking about and writing about research, as well as learning about the basic structure of research papers. However, research papers are very dense and can be difficult to understand, even for native speakers of the language, so one challenge was presenting the information in ways that intermediate-level English students could understand. Another challenge was the lack of laboratory equipment and facilities.

The goal for this course was not to teach academic writing nor how to analyze research papers since that would be beyond the scope of this course. Achieving those goals would require that students have a higher English level and the entire course would need to focus solely on those topics (Spack 1998; Lacum, et al 2014; Levis and Levis 2003; Brown 2004). Instead, the goal of this course was to use project-based learning with a project related to science and engineering to help introduce students to the basics of academic writing and how to talk about research in English (Alan and Stoller 2005; Dhieb-Henia 1999). This is useful for students because, for many, one important use for English in their future jobs will be reading academic journals in their field of work. The students were able to practice some academic writing by composing a very basic version of a research article based on their experiment.

The experiments were not designed by the teacher and given to the students. Instead, the students had to come up with an idea for their own experiment, which was challenging for many students. This was also a challenge for the teacher because some students proposed ideas that were not actual experiments. For example, some students just wanted to do a survey or carry out a demonstration that they already knew the results of. Conversely, some students were too ambitious with their experiment or wanted to do something that would be fairly expensive to do. Therefore, the students needed guidance and time to come up with a feasible experiment. For this reason, the planning part of the experiment took place over the course of several weeks alongside regular English lessons. In other words, the experiment project was not the main focus of the course, but rather a supplemental project.

Students were shown four example experiments from past students to help them come up with ideas, since that was a challenge for many students. However, the students were strongly encouraged to come up with their own ideas and not to copy the example experiments, because an important aspect of the experiment project was that students should design an experiment that they are interested in and genuinely want to know the results of. Without this aspect, the students would have little motivation to plan their experiments and learn the English necessary for talking about their experiment plan and results.

## Methods

The experiment project was carried out during a 16 week course. Below is the basic schedule that was used for the experiment project. As mentioned above, this project was a supplemental part of the course, so the activities below were carried out alongside regular English learning activities.

**Week 3 class.** The experiment project was introduced to students in Week 3 of 発信英語 IV. During the Week 3 class, students were shown experiments from students who had taken the course in the past in order to help the students think of their own experiment. This was very important because there are many possibilities, and it can be overwhelming for the students. In addition to actual student experiments from the past, current students were also shown fake “bad examples” to help them avoid choosing experiments that were too easy or something that was not actually an experiment. As part of their homework for the Week 3 class, students were instructed to write a basic idea for their experiment in 2 - 3 sentences and write an additional 1 - 2 sentences to give a reason why they decided on that experiment. In order to keep students from getting too stressed about choosing their experiment idea, it was also stated that the students would have a chance to change their experiment idea in the future. For grading of the Week 3 homework, the teacher did not evaluate the experiment idea itself, but rather evaluated the written explanation of the experiment idea and reason, and for proper use of grammar in their sentences.

**Week 4 class.** Before the Week 4 class, the teacher reviewed the students’ experiment plans from the Week 3 homework and looked for common problems among them and made additional fake “bad examples” with some of the common problems that were present in the students’ experiment plans. These bad examples were then

shown in the Week 4 class in order to avoid directly criticizing individual students' experiment plans. It was also explained how the bad examples could be turned into good experiments by adding and or changing parts of the experiments. The students did not work on their experiment plans during the Week 4 class, but they were encouraged to continue thinking about how they could improve their experiment plan. Even though they didn't work on their experiment plans during the Week 4 class, example experiments from a textbook were used to help students start thinking about experimental methods, and how to write methods in the future tense since they would need to do that for their experiment plans.

**Week 5 class.** The same example experiments from a textbook used in the Week 4 class were used again. This time, the example experiments were used to help students learn some common words used in experiment methods, such as variables, control sample, and sample size. For one of the activities with the example experiments, the students were told to imagine that they were going to do the experiments. The methods in the example experiments were not greatly detailed, so the students were told that they should make a list of additional details that they would need to know in order to carry out the experiment. The purpose of this activity was to get them to practice taking a more rigorous approach to planning in order to help them think about their own experiment plans in more detail. For the Week 5 homework, students wrote the variables, control sample, and sample size for the experiment they were planning using complete sentences. They were also told that they could still change their experiment idea at this point. For grading of the Week 5 homework, the teacher evaluated the written explanations of the required information, and whether the student had given sufficient thought to the required information.

**Week 6 class.** The students were told how to write a hypothesis for an experiment, and the example experiments from a textbook were used again so the students could practice writing hypotheses (the students did not yet know the results of the example experiments). The students were given individual feedback by the teacher about their experiment plans. Then, for the homework, they wrote 5 - 8 sentences for the methods for their experiment plan using the future tense and wrote a hypothesis for their experiment. The students were told that this would be the last chance to change their experiment idea. For grading of the Week 6 homework, the teacher evaluated the written explanations of the methods, including correct use of future tense grammar.

**Week 7 class.** The students worked on a presentation about their experiment plan. The presentation would be given during the Week 8 class and was supposed to include the reason they chose the experiment and a general explanation of the methods.

**Week 8 class.** The students gave a 3 - 5 minute presentation about their experiment plan. See Appendix 1 for the Week 8 presentation grading rubric (Presentation skills, such as eye contact and posture, were introduced and explained in earlier lessons).

**Weeks 9 - 12 classes.** The students were supposed to carry out their experiment during this time period. For some students, the experiment could be completed all at once, but some experiments took place over the course of several days or weeks (examples of student experiments are included in the Results and Conclusion section below). The experiments were done outside of class. Regular lessons were held during this time period. There was no specific lesson content related to the experiment project during this time period.

**Week 12 class.** The students were introduced to the basic organization of research articles (Introduction, Methods, Results, and Discussion) with a focus on the Introduction and Methods sections in this class. For the Introduction section of their research articles, the students were told to find some background information related to their experiment topic. For homework, the students were instructed to write a basic version of an Introduction section (5 - 8 sentences) and they rewrote their methods in the past tense. They had previously written their methods in the future tense in Week 6 for their experiment plan, but at this point, they should have finished their experiments, so they rewrote the methods in the past tense and made changes to the methods if they ended up doing something different than they had originally planned in Week 6. For grading of the Week 12 homework,

the teacher evaluated the content of the Introduction section and for the Methods section, correct use of the past tense was evaluated.

**Week 13 class.** The students learned more about the Results section of a research article and different visual aids to show results (e.g. tables, charts, pictures). The importance of using the past tense in reporting results was also explained. The example experiments from a textbook were used again, this time the results of the example experiments were included. For homework, students wrote about the results of their experiments and submitted a table, chart, or picture as a visual aid to illustrate their results. For grading of the Week 13 homework, the teacher evaluated the written explanation of the experiment results, including the correct use of the past tense. Also, the visual aids were evaluated for clarity and appropriateness.

**Week 14 class.** The students learned more about the Discussion section of a research article and the types of information that are typically included in Discussion sections. For homework, the students were told to include the following information in the Discussion section of their research articles: possible reasons for the results; how the results differed from their hypothesis; and what the next step in their research would be. The students were not expected to actually continue their research, but they were supposed to envisage that they would continue their research. This homework was the final section of the research article part of the experiment project. In addition to the homework, the students also began preparing for a research presentation on their experiment. The students were told how to adapt their research articles for a presentation, but most of the content was the same. For grading of the Week 14 homework, the teacher evaluated the explanations in Discussion sections for the required information written above, and for appropriate use of grammar.

**Week 15 class.** The students practiced talking about their experiment results with a partner and continued to work on their research presentation. For homework, the students submitted slides for their research presentations and they were supposed to practice their presentations.

**Week 16 class.** The students gave a 4 - 6 minute presentation, including slides, about their experiment to the class and answered questions from other students about their experiments. See Appendix 2 for the Week 16 presentation grading rubric.

## **Results and Conclusion**

The students were able to come up with a wide variety of experiments, and most were able to successfully carry out their experiments. For students who did not get good results, they were still able to analyze their experiment and speculate about possible problems in their experiment design and how they could change their plan if they were going to try to do the experiment again. Most of the experiments fell into the following categories: Cooking-related, Learning-related, Chemistry-related (with household items), or Lifestyle-related. Some of the experiments are listed below with basic summaries to show how students were able to complete the project with minimal cost.

**Student experiment 1.** Cooking-related: Flavor simulation. A student tried to simulate the flavor of certain foods. Two types of food were mixed together to attempt to simulate the flavor of a different food. For example, adzuki bean paste and butter was mixed to try to simulate the flavor of sweet potato. The student got the idea from information on the internet, and they tried to simulate five different flavors. For evaluating the results, the student had six different people try the flavor combinations and each person rated whether the desired flavor was simulated successfully, somewhat successfully, or not successfully.

**Student experiment 2.** Chemistry-related: Cleaning 10 yen coins. A student tried using common condiments and drinks to clean oxidized 10 yen coins in a chemistry-related experiment. The student evaluated the results by taking pictures of the coins before and after soaking the coins in the various liquids.

**Student experiment 3.** Math-related: Dice accuracy. A student wanted to compare the accuracy of cheap dice and expensive dice in a math-related experiment. They rolled dice hundreds of times and recorded each result, then compared the overall results to the expected distribution.

**Student experiment 4.** Learning-related: Memorization strategies. A student compared two different methods for memorizing a long string of numbers. The student asked six other students to participate in their study. The students first tried to memorize a long number by reading it aloud many times, then they tried to write as much of the number as possible five minutes later. The other method was to write a different number many times and then try to write as much of that number as possible five minutes later.

**Student experiment 5.** Lifestyle-related: Waking up. A student tried doing different things after waking up in the morning to see what would help them feel most refreshed. This study required several weeks so that the student could try one method every morning for a week, then switch to a different method the following week, and so on. To evaluate results, the student came up with a ranking system to help quantify how refreshed they felt.

There were some drawbacks to the experiment project. Even though students were encouraged to come up with their own experiment ideas, some students copied most of their experiment plan from the examples that were shown in Weeks 3 and 4. Despite this, showing example experiments to the students is still worthwhile, because most students need to see examples in order to come up with a feasible experiment on their own. There were also some cases where students may have fabricated results without actually doing their experiment, so it may have been useful to introduce research ethics before the students did their experiments. However, even if a student fabricated their results, they still had to write about their experiments, and they were graded based on what they wrote. Finally, there were some students (about 20%) who did not like the experiment project and would have preferred to spend more time on typical textbook activities, based on a survey given to the students at the end of the course. It was not possible to follow up with those students and find out why they did not like the experiment project, but for some, they may not have been able to come up with an idea that they found interesting or their experiment may not have worked as well as they had hoped. Or some students may just feel more comfortable with traditional English class activities.

Overall, the experiment project was successful and many students were able to design and carry out interesting experiments. The students also were exposed to academic writing and were able to practice writing and talking about research and experiments in English. This project was mostly done by science and engineering students, but it would be possible to do it with ESL students from other fields of study since many of the students' experiments in this study did not require a high level of scientific knowledge.

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## Appendix 1. Grading rubric for the Week 8 presentation

### Week 8 Experiment plan presentation

#### Presentation grading

Scores:	S = Very good	90 - 100%
	A = Good	80 - 90%
	B = Okay	70 - 80%
	C = Needs some improvement	60 - 70%
	D = Needs a lot of improvement	< 60%

#### Content

##### Introduction

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| ■ Was the purpose of the experiment clear? | S | A | B | C | D |
|--|---|---|---|---|---|

##### Body

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| ■ Did the speaker explain what they are going to do? | S | A | B | C | D |
| ■ Were the methods clear?                            | S | A | B | C | D |

##### Conclusion

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| ■ Did the speaker give their hypothesis? | S | A | B | C | D |
|--|---|---|---|---|---|

#### Delivery

##### Eye contact and posture

- |   |   |   |   |   |   |
|---|---|---|---|---|---|
| ■ Did the speaker make eye contact with the audience? | S | A | B | C | D |
|---|---|---|---|---|---|

##### Pronunciation, talking speed, word choice, and grammar

- |                                       |   |   |   |   |   |
|---------------------------------------|---|---|---|---|---|
| ■ Was the speaker easy to understand? | S | A | B | C | D |
|---------------------------------------|---|---|---|---|---|

#### Overall

- |                                  |   |   |   |   |   |
|----------------------------------|---|---|---|---|---|
| ■ Was the speaker well-prepared? | S | A | B | C | D |
|----------------------------------|---|---|---|---|---|

Presentation time: \_\_\_\_\_ (Goal: 3 - 5 minutes)

## Appendix 2. Grading rubric for the Week 16 presentation

### Week 16 Experiment results presentation

#### Presentation grading

Scores:	S = Very good	90 - 100%
	A = Good	80 - 90%
	B = Okay	70 - 80%
	C = Needs some improvement	60 - 70%
	D = Needs a lot of improvement	< 60%

#### Content

##### Introduction

- Was the topic and purpose of the experiment clear? S A B C D

##### Body

- Was the background information helpful? S A B C D
- Were the methods and results explained clearly? S A B C D
- Did the speaker interpret their results? S A B C D

##### Conclusion

- Did the speaker explain their future research plans? S A B C D

#### Delivery

##### Eye contact and posture

- Did the speaker make eye contact with the audience? S A B C D

##### Pronunciation, talking speed, word choice, and grammar

- Was the speaker easy to understand? S A B C D

#### Overall

- Were the slides clear and easy to understand? S A B C D
- Was the speaker well-prepared? S A B C D

Presentation time: \_\_\_\_\_ (Goal: 4 - 6 minutes)