Terashima A. V., O'Brien, M. O. (2016). Experiments as a springboard for academic writing. The Joint International Conference of the 8th International Conference on ESP in Asia & the 3rd International Symposium on Innovative Teaching and Research in ESP in Japan, Tokyo, August 19, 2016. Tokyo: UEC IGTEE Research Station. Vol. 1, 72-76.

Experiments as a Springboard for Academic Writing

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Abstract

The Active Learning of English for Science Students (ALESS) course at the University of Tokyo, teaches academic writing in the IMRaD research paper format. Students design and complete an original experiment as a basis for their writing. During class, students are guided through the process of developing an idea and hypothesis for their experiment, as well as taught the basics of experimental design, data analysis and interpretation. The hands-on experience of independent academic research increases student understanding the research paper genre, facilitating self-motivated learning. Students are challenged with researching a scientific topic and explaining their ideas and findings to their peers orally and in writing. In this workshop, we discuss how incorporating simple experiments into an ESP academic writing course increases student engagement with the course content. Additionally, we demonstrate specific examples of class activities and discuss the range of experiments undertaken by ALESS students.

Key words: academic writing, curriculum and course design in ESP, English for Specific Purposes, IMRaD, scientific experiment

I. Introduction

The ALESS (Active Learning of English for Science Students) Program was established in 2008 at the University of Tokyo, and is a compulsory writing class for first year undergraduate science students, introducing them to the genre and rhetoric of scientific research papers in English (Allen, 2012). It is a 13-week course, taught once a week for 105 minutes. Currently, there are approximately 20 full time, fixed-term assistant professors teaching ALESS. Therefore, while roughly 1,850 students take this course each year, one class consists of approximately 15 students. In this setting, active learning, group activities and class discussions are emphasized.

Although the ALESS course largely focuses on teaching academic writing, and incorporates additional activities such as peer-editing, peer review and oral presentation, this workshop focuses primarily on the first portion of the course which teaches basic experimental design and guides students through the process of selecting a research question for their experiment. To our knowledge, this aspect of the course is not common in other writing programs, and our aim is to provide guidance for other institutions interested in incorporating a similar project-based learning approach into their classrooms.

After achieving a bachelor's degree, over 75% of University of Tokyo undergraduates continue their studies in graduate school (Gally, 2009). While many of the students will not be required to write in English until their 4th year, or even until graduate school, the aim of the ALESS program is to teach skills that will be applicable in other contexts and classes (for example: ability to find and read scientific articles, basics of experimental design, critical and logical thinking, collaboration and time management).

Over the course of 13 weeks, students need to choose a topic, design and carry out an original experiment, write a research paper, peer-review a draft of another student's paper and present their findings in a formal oral presentation. For many students, it is the first time that they experience these activities as well as the first time they experience a class taught fully in English. For these first-year undergraduate students, it is perhaps the first time that they are asked to take responsibility for their own learning and make meaning of the knowledge and concepts they encounter. To do this successfully, they must make the shift to become active,

self-regulated learners (English and Kitsantas, 2013). This requires motivation, focus and a realization that they are responsible seeking out help when they need it. It is the hope of the ALESS program that the experiment, which focusses on a research question chosen by the students themselves, serves as a motivational tool that helps students make the shift, and maintain focus and engagement throughout the semester. The additional support students may need takes shape in two support centers that are vital for the success of ALESS, the ALESS lab and the Komaba writers studio.

II. Support outside the classroom

The ALESS program has two, self-access support centers that, while open to all ALESS Program students, are not compulsory and serve to aid students seeking additional help. The ALESS Lab is a dedicated science laboratory managed by a research scientist and staffed by 25 graduate science student teaching assistants (TAs). Students can drop-in for a consultation (in Japanese) regarding planning and carrying out their experiment and interpreting results. The lab also has various basic equipment that can be used on site or borrowed by the students for the duration of their experiments. In 2015, there were over 4,000 consultations at the ALESS Lab.

The Komaba Writers studio is coordinated by a faculty member and staffed by 20 graduate student TAs who provide 40 minute consultations primarily for writing but also speaking support. As David Allen, a former member of the ALESS faculty, described it in 2013 "KWS, which operates primarily in Japanese and […] can work as a psychological and practical support for students, itself a space for joint teaching and learning (and not only in the mechanics of writing), as well as an important site for graduate students to engage in tutoring undergraduate students through constructive dialogue" (Allen, 2013). In 2015, KWS conducted over 2000 consultations. In end-of-semester questionnaires, students often respond that they found both resources useful.

III. Experimental design and choosing a research question

The ALESS course is centered around the writing of a short IMRaD-style paper (Introduction>Methods> Results>Discussion) that is based on an original experiment that the students themselves design and carry out (either in groups or individually). The ALESS course does not use a textbook, instead, class content and materials are developed and adapted by the faculty through continuous collaboration (Gally, 2009).

The first task the students need to complete is to choose a topic for their experiment. They usually brainstorm ideas for research questions and discuss potential experiments based on these questions with their peers. Many students use their personal interests as a starting point for brainstorming ideas, and then discuss potential experiments and whether they are feasible with their classmates and TA's from the ALESS Lab to refine narrow-down their questions. The ALESS program publishes an annual collection of 10-12 student papers recommended by the faculty (ALESS Collection) and students can use this as a resource for topic ideas. Additionally, some students base their experiment on a gap they observed in a previous ALESS paper.

Research question selection typically happens in the first three weeks of the semester. In this time, students need to understand how to build a research question and propose a hypothesis that is supported by existing literature. The students are introduced to basic elements of experimental design (hypothesis; independent, dependent and controlled variables; subjects and objects, etc.) and asked to find previously published research related to their topic of interest. Because many students do not have experience of searching for academic papers online, or reading them, this needs to be explained and demonstrated as well. Once they have some understanding of what is already known about the topic, they have to formulate a hypothesis and provide an explanation of why they think the hypothesis would be true. In other words, it is stressed that the hypothesis is rooted in previously established knowledge, rather than pure conjecture. The topic of the experiment is restricted by several factors including limited time to conduct experiment, safety considerations, and availability and accessibility of equipment. The experiment must be hypothesis driven, rather than exploratory, that is based on a prediction "If A is manipulated, the outcome will be B." rather than "What will happen if A is manipulated" in order to make experimental design more straightforward and because it emphasized that some prior knowledge (i.e. background reading) is needed before formulating a hypothesis and designing the experiment.

Some professors restrict topics to their own area of expertise. For example: for a professor with a background in biology, students can choose from several specific areas such as plants, bacteria, fungi, food,

insects, and so on. However, it is important to emphasize that, as Tom Gally, one of the founding faculty of the ALESS program, writes "While sometimes the experimental topics chosen by students can be rather specialized and require technical vocabulary to explain, most are readily understandable to the other first- year students in the classes as well as to the teachers (many of whom do not have formal scientific backgrounds). As a result, both other students, during in-class peer review, and the teachers are able to consider not only the papers' formal characteristics, such as grammar, rhetoric, and organization, but also their content, including, most importantly, the descriptions of experimental methods and results and the arguments used to support the authors' scientific claims" (Gally, 2011).

Students are strongly encouraged to select an original research question, meaning that the answer is unknown, and to design a simple and inexpensive experiment to try to answer the question using everyday items. Several restrictions are in place regarding the experiments, both to help students design experiments that can be done in a reasonably short time frame (3-4 weeks) and to avoid any safety issues. To this end, some of the restrictions include: location-the experiments must be conducted either at the student's home or on the Komaba campus; no vertebrate animals can be used in experiments, students must not taste any experimental products or ask anyone else to do so (in cases of experiments with food), no activities that can endanger individuals, lead to destruction of property or violation of privacy. To ensure that students adhere to these guidelines, students have to describe their experiment on a safety form, which is checked by the instructor and a designated safety officer before experiments can proceed. This procedure serves to safeguard against any potentially dangerous or prohibited experiments. Further considerations include a time restriction—students are expected to complete their experiments in 3-4 weeks, using a budget of ¥2,000 and use materials they have access to in their homes, grocery or hardware stores or the ALESS lab.

Considering these restrictions and the fact that students must decide on a research topic and design an experiment in the first four weeks of the semester, ALESS experiment topics have been creative and cover a broad range across many scientific fields (Table 1).

Table 1. Examples of scientific fields and respective research questions used as basis of ALESS experiments.

Physics	How does the braiding pattern affect the strength of braided yarn?
Chemistry	How does the cooling speed of a solution affect the formation of crystals on a wire?
Biology	How does the temperature of green tea infusion affect its antibacterial activity?
Linguistics	Does making mistakes enhance second language learning?
Food Science	What is the rate of swelling of ramen noodles in proportion to time?
Plant Science	Are Venus fly traps affected by muscle relaxers?
Insect Behavior	Can ants tell the difference between natural and artificial sugar?
Computer Modeling	How does the arrangement of buildings affect the speed of wind between the buildings?

In summary, in the first four weeks of the semester, students brainstorm for topic ideas, find a research paper related to their topic of interest, come up with a hypothesis based on previously published knowledge and design an original experiment to test their hypothesis.

IV. Outcomes

As might be expected, many experiments often fall short of the rigor of actual scientific experiments. First year undergraduate students have little or no experience in designing and carrying out experiments and have to perform their ALESS experiment with little or no supervision, however, this is not a great concern because the science is not the focus of this class. Moreover, students experience firsthand that scientific progress rarely proceeds smoothly and requires frequent troubleshooting. Regardless of experimental outcome, all students can write a paper about their experiment. If the experiment does not work according to expectations, students gain greater insight into the limitations and possible explanations of their results and can discuss improvements that could be made if the experiment was to be repeated in the future.

Every year since 2010, ten to twelve best examples of student papers are published in the ALESS collection, a printed magazine intended to be a source of inspiration and aspiration to students in the subsequent semesters. Students can examine all the prior volumes of the ALESS collection to get an idea of what kind of experiments are possible and to have a better understanding of the kind of paper they are expected to write. It also potentially serves as additional motivation to students who would like to see their own paper printed in the following collection.

V. Challenges

The major challenge that comes with incorporating an experiment into a one semester writing course is that it leaves less time for writing. While this is a topic of discussion among the ALESS faculty, most agree that the value added by having students conduct experiments as the basis of their writing merits its inclusion in the curriculum.

Another concern is low scientific value of some research topics. These are topics that have predictable results, are of little scientific interest, or have poor experimental design resulting in little or no data (for example: Are bananas with brown spots more sweet? What is the optimal shape for paper airplanes?) Some students put minimal effort into coming up with a research question or fall back on project ideas that have been done before, either due to a lack of motivation or lack of confidence in their English skills (and intimidation of reading scientific papers in English). To meet the challenge of fostering scientific creativity and thinking, several useful activities such as brainstorming sessions in class, as well as peer and graduate student feedback on research proposals are implemented in ALESS (Gally, 2009).

Although experiments are done outside of class, students conduct an original experiment and synthesize information from several research articles, therefore cases of plagiarism are rare. The ALESS program maintains a database of all student papers, and newly submitted papers are checked for similarity against the database, discouraging students from using papers written by students in previous semesters.

Additionally, there is a possibility of students committing data fraud and fabricating the results of their experiments. ALESS instructors take several actions to forestall this from happening, such as requiring students to maintain a lab notebook, take photographs of their experimental progress, working in groups and in the case of experiments with human participants, asking students to collect informed consent forms. Nonetheless there is a level of assumed trust between the instructors and the students that exists in the course following an explanation of ethical conduct in research and the penalties for data fraud and plagiarism. Ethical conduct in scientific research is a vital skill that students will need to learn and we hope that taking personal responsibility for their experiment in ALESS is a step in the right direction.

VI. Conclusions

At its core, the focus of the ALESS program is on teaching writing rather than science. The experiments students do as part of the class are a tool rather than the goal of the class. It provides students with material to write about and helps them have more engagement with class material. Therefore, while we aim to teach elements of good experimental design (e.g., hypothesis, variables, controls, replication, sample size, etc.), we do not evaluate student papers on the validity of their science. We do however, evaluate logic of their arguments, claims supported with evidence and understanding of the IMRAD format.

In conclusion, although incorporating a science experiment into an academic writing course and essentially giving students the freedom to choose the content they want to focus on, is challenging and may require providing students with support outside the classroom and beyond the instructor alone, however in our experience it serves as a motivating factor for student engagement with the program and therefore is a worthwhile investment.

Acknowledgements

We wish to thank all members of the ALESS faculty past and present, as well as the staff and TAs who support the program. Additionally, we would like to thank the Global Faculty Development Committee of the University of Tokyo for providing funding to attend the Joint International Conference on ESP in Asia 2016.

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