Science Tutorials in an English-Language Program for Science Students

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Introduction

English has become the common language of the scientific community, and scientists are usually required to publish their findings in academic journals in English. Many efforts have been focused on improving the English-language skills of future and working scientists from non-English-speaking countries. However, by focusing mainly on linguistic and communicative issues, the contributions of language educators have often overlooked some important elements of the scientific process: the transmission of knowledge and expertise within scientific communities—especially small-scale, local communities, such as laboratories, research teams, and people in mentor-mentee relationships—and the connection of that transmission process to the acquisition and use of linguistic skills such as research-paper writing. In this paper, we look at how scientific knowledge and expertise are transmitted within a pedagogical context that replicates many of the features of actual scientific communities, and we discuss the role that English-language education can play within the scientific process.

Scientific communication

The primary medium for conveying the results of scientific research is the research paper. As explained by the Brazilian educator Marcos Villela Pereira, the purpose of a scientific paper is to convince the readers of the reliability of the obtained results and to assert that the discoveries are true (2013, p. 218). To be accepted by scientists as truths, the phenomena described in a paper need to be rigorously investigated not only by the paper's authors but also by other individuals and institutions. Scientific writing, as the applied linguist Caroline Coffin has stated, is therefore characterized by rigid expectations for particular text types (2005, p. 49), with the language, structure, and format of scientific papers being largely standardized so that knowledge can be extracted from them easily and so that the claims of different papers can be compared.

Perhaps the most conventional overall structure for scientific papers is IMRaD—Introduction, Methods, Results, and Discussion. The Introduction section explores the background of the topic, discusses what is known and unknown about it, and raises a research question. This research question is explored based on a hypothesis that usually involves a prediction, suggesting a possible way to answer the research question. The Methods section contains all the necessary information—including materials, conditions, and procedures, which are usually listed chronologically—so that other scientists can obtain the same results if they follow the methods presented in the paper. The obtained results are usually presented in the Results section, with raw data being processed statistically and presented in the form of figures or tables so that readers can easily and visually understand the results. In the Discussion section, the obtained results may be compared with those of previous research and are interpreted with reference to the hypothesis. Descriptions of possible improvements to the research or pathways for future study are also important topics for this section (Coffin, 2005, p. 23). The body of the paper usually ends with a Conclusion section, where the findings are summarized. With some variation—sometimes the Results and Discussion sections are combined, for example, or the detailed methodology might be relegated to an appendix—scientific papers are generally structured in this way.

Each of these sections is written based on certain rhetorical rules and registers. For example, in the Introduction, the present tense is used to describe known and unknown information, while the past tense is used to refer to the results of previous studies (ALESS, 2012, p. 83). The Methods section is usually written in the past tense, except for previously known facts, and with verbs in both the active and passive voices (ALESS, 2012, p. 104). The Results section begins with the most important result that answers the research question raised in the Introduction (ALESS, 2012, p. 122). Throughout the paper, an objective tone is used, with little or no suggestion of the authors' subjective perceptions or views.

These linguistic features of English-language scientific papers create challenges for many scientists who use English as a second or foreign language. The use of tense in English, for example, can be difficult for native speakers of Japanese, in which aspect rather than tense is grammatically dominant. The emphasis on an objective, impersonal tone can also be problematic for scientists who have mainly learned English through pedagogies that emphasize everyday conversation and the expression of personal opinions.

Scientific methods

The conventions of scientific writing in English are not arbitrary. Rather, they are closely related to the process of science itself and how scientists perceive reality. Science is generally supposed to be the pursuit of an understanding of the world, which is presumed to have order and regularity. Elucidating its mechanisms is considered to mean getting closer to the truth in order to promote human progress.

Yet, as the physicist Ukichiro Nakaya has pointed out, science is not almighty. One cannot explain all natural phenomena with science; one can say that something is true only when one's obtained knowledge is consistent with the knowledge obtained by others (Nakaya, 1958, p. 2). While denying the existence of ultimate reproducible phenomena, Nakaya also stated that the scientific method functions to solve problems only when reproducible problems are extracted from natural phenomena (p. 2). Therefore, a scientific discovery may said to be the perception of something as a truth only when it is reproducible.

Nakaya also said that one of the features of the scientific method is quantification (p. 3). Once natural phenomena are quantified, they can be investigated using mathematics. According to Nakaya, physics is considered to be the basis of science, and the basis of physics is measurement. Therefore, the basic scientific method is to extract and to investigate certain phenomena by measuring them (Nakaya, 1958, p. 40). In this view, the basis of the scientific method is extracting quantifiable phenomena, and being a scientist means perceiving the world by means of quantification.

This is why science requires skills that are usually not present in the humanities or in some of the social sciences, such as using instruments, keeping laboratory notebooks, and making graphs. The development of such skills is, hence, critical for young novice scientists, and often those skills are nonlinguistic. In a case observed by Tomoharu Yanagimachi in a laboratory at a Japanese university, for example, a professor tried to teach a technique for performing an experiment to a student who was not a fluent speaker of Japanese; rather than explaining the technique in words, the professor told the student to learn it by looking at the demonstration carefully (Yanagimachi, 2006, pp. 132–133). The philosopher of science Thomas S. Kuhn similarly stated that scientific terms should be presented together with concrete examples of how they function in use so that the phenomena and the language can be learned together (Kuhn, 1970, p. 191).

Furthermore, Kuhn said that a scientist must work to solve problems about the behavior of nature, and that the solutions must not be personal but must be accepted by a group of professional peers (Kuhn, 1970, p. 168). What is more, he wrote, a novice must learn the methods of science through social relationships in a group:

> Looking at a contour map, the student sees lines on paper, the cartographer a picture of a terrain. Looking at a bubble-chamber photograph, the student sees confused and broken lines, the physicist a record of familiar subnuclear events. Only after a number of such transformations of vision does the student become an inhabitant of the scientist's world, seeing what the scientist sees and responding as the scientist does. The world that the student then enters is not, however, fixed once and for all by the nature of the environment, on the one hand, and of science, on the other. Rather, it is determined jointly by the environment and the particular normal-scientific tradition that the student has been trained to pursue. (Kuhn, 1970, pp. 111–112)

In short, learning the methods for science means learning from experienced members about how to perceive scientific reality. Thus, a group of people doing science, usually called a scientific community, has its own way of thinking and behavioral patterns that novices must learn from members of the group in addition to learning the appropriate language.

This community, however, is not a single group, but consists of multiple subgroups. A novice—often a science student at a college or university—may encounter a professional scientist for the first time in a university science class. He or she may take several science-related classes and have different scientists as instructors. Later, the student might have an advisor for research and join the advisor's laboratory. The person will also have many colleagues who are science students, postdoctoral researchers, or professional scientists. He or she will have opportunities to get to know scientists from other laboratories or institutions as his or her academic activities outside the campus increase. The novice scientist may join a private study group after school or after laboratory work. The individual thus encounters various scientific groups in the course of learning and professionalization.

This process for developing scientists is not restricted to science classes or laboratories. As the anthropological linguist Jay L. Lemke has suggested, people in most communities must actually participate in multiple communities or practices in order to master or to be counted as having mastered the practice of a certain community (1997, p. 43). Those communities do not need to be orthodox, mainstream communities; even a peripheral community, such as the one described in this paper, may provide novice scientists with an important learning environment.

In light of these perspectives, this paper aims to understand a scientific way of interpreting the world though the interactions between science teaching assistants and students taking an undergraduate class in English-language scientific writing and presentation. The paper also explores the significance of providing science students with opportunities to learn the principles of science in an English-language program.

Investigation site

We conducted our investigation during the school terms from

October 2014 to June 2015 at the ALESS Lab, a support facility for the Active Learning of English for Science Students (ALESS) program at the University of Tokyo (UTokyo) in Japan. ALESS is a one-semester course in English writing and presentation taught to all first-year UTokyo undergraduates who expect to major in the natural sciences, medicine, or engineering (about 1850 students each year). In the 13 once-a-week class meetings, the students are introduced to the structure and language of scientific papers and, by the end of the semester, write their own papers in the IMRaD format and give presentations to their classes about the content of their papers. Those papers and presentations are based on simple scientific experiments that the students themselves devise and conduct, either individually or in small groups, so the course syllabus also includes the basics of experimental design. The syllabus has been designed and refined by the ALESS faculty, who are themselves experienced researchers and have advanced degrees in fields such as chemistry, biology, and medicine as well as applied linguistics and other areas of the humanities and social sciences.

The ALESS class is, perhaps needless to say, considerably challenging to most of the students, very few of whom have ever even seen a scientific paper in English before taking the course, let alone written one, and most of whom have never had to come up with an original experiment on their own. The university has therefore established two support facilities to assist students with the ALESS assignments outside of class: the Komaba Writers' Studio, a writing center where students can make reservations to receive one-to-one tutorials with graduate-student teaching assistants, and the ALESS Lab. The ALESS Lab's main role is to help the students enrolled in ALESS to design and conduct their experiments and to analyze their results so that they can complete their papers by the end of the term. The Lab is equipped with consultation space and some basic experimental equipment, including microscopes, analytical balances, a spectrophotometer, and a constant temperature bath. Some of the equipment, such as thermometers and hygrometers, can be borrowed by students for use at home or elsewhere on campus.

The main role of the Lab is the consultation provided by the teaching assistants (science TAs), who are graduate students majoring in science at UTokyo. Currently, the Lab is staffed with about 20 science TAs under the supervision of a manager who has a Ph.D. in chemistry. The specialties of the science TAs vary from biology, chemistry, and physics to mathematics, psychology, and the history of science. The manager is responsible for running the Lab, organizing the staff shifts, taking care of difficult consultation cases, and other miscellaneous tasks.

The Lab is open from 12:00 to 3:00 p.m. on weekdays during the semester. The students can come to the Lab without prior booking. Generally, two to three TAs work at a time in one-hour slots. The manager or a receptionist assigns one TA to each student or group, and the students and TA sit together at one of the small round tables in the middle of the room. The typical length of a consultation is about 10 to 30 minutes.

The students start visiting the Lab to ask for advice soon after the semester begins. During the first two weeks or so, the main topic of the consultations is how to find research papers that can serve as background for their studies. The TAs introduce important journals in the target fields and suggest keyword choices for online searches. From the third week, the main topic of the consultations gradually shifts to how to design the experiments. At this stage, the TAs provide practical advice on doing experiments by giving concrete examples; the goal is to ensure that the students will be able to finish their experiments and obtain their results by around the middle of the 13-week term. Most of the students are encouraged to perform their experiments at home or on campus using everyday materials. In addition to checking out smaller equipment for use elsewhere, some students are assigned a small workspace in the Lab itself so that they can use nonportable instruments, such as the constant temperature bath or high-precision scales. In this case, at least one TA with knowledge and experience is assigned to give advice on managing the workspace and handling the instruments. Finally, from around the sixth through ninth weeks, many students come for advice on the results they have obtained. The most frequent questions at this stage are how to analyze the data statistically and how to present the data in a graph or table. Once students have their data ready to write up, they are more likely to seek help with the actual writing at the Komaba Writers' Studio, so the Lab becomes less busy. In all of the consultations, both the science TAs and writing TAs try not to interfere with students' ideas or to give instructions that conflict with those given in class by the ALESS instructors.

Photograph 1: The ALESS Laboratory crowded with students and TAs. The consultation tables are in the center of the room, and the experiment workspace is along the wall.

Data collection

In order to learn what actually takes place during consultations at the ALESS Lab, researchers visited the Lab once or twice a week and observed tutorials during the school terms from October 2014 to June 2015. The major participants were science TAs, who were all UTokyo graduate students in the natural sciences, and first-year undergraduates enrolled that semester in ALESS. Twelve tutorials between science TAs and students were observed and recorded on both audio and video. Additionally, after each tutorial observation the researchers either interviewed the science TAs or asked them to fill out a questionnaire. All of the participants gave written consent for data collection. Since the researcher who mainly conducted the data collection was not familiar with the Lab, the Lab manager introduced the researcher to TAs and played the role of a gatekeeper. The researchers also made an effort to fit in with the TAs, such as talking with them when they were free and helping out with reception work when the Lab was busy. In many cases, the researchers could observe sessions freely, but the manager sometimes told the researchers not to observe certain sessions because of the circumstances of the students and TAs or the crowdedness of the Lab.

During the tutorial sessions, the researchers used a video camera for visual recording and a laptop computer for audio recording. The video camera was fixed next to the consultation table, and the computer was placed on the table around which the participants sat. When necessary, such as when students and the TA stood up from the consultation table and walked to a shelf to fetch an instrument, the researchers panned the camera to follow them.

The collected data consisted of audio and video recordings of 12 tutorial sessions and field notes taken by the researchers. The audio and video recordings were transcribed and annotated for analysis using ELAN (Brugman & Russel, 2004). This paper focuses on three sessions that represent typical science tutorials at the Lab and that illustrate how students who take part in the tutorials are guided to a better understanding of the scientific process.

Science tutorials

Tutorial S01: *Dō yatte hyōka suru no ka*

TA01 was a graduate student in a chemistry-related doctoral program and a teaching assistant with more than two years of experience in tutoring at the Lab. When three students, A, B, and C, came to the Lab in a group, the Lab manager introduced the students to TA01, who was free. All three students were first-year science undergraduates taking the ALESS class. The three students and TA01 sat around a small round table in a corner of the room.

TA01 began the tutorial by asking if they had come today for advice on their experiment. His way of starting the conversation was nice and friendly. His personality elicited smiles and laughs from the students, and they answered yes in chorus. TA01 then asked a further question: Had they come up with any concrete ideas for their experiment? In response, student B said they had several ideas, and they would like to hear the TA's comments about which experimental design was most feasible.

While student B explained their ideas, the other two students kept quiet. It seemed that students A and C were leaving the leadership to B. But then B encouraged A and C to explain their other ideas so that each student would be making a contribution, and the group mentioned a total of five research ideas relating to food: the relationship between sweetness and peel browning of bananas; the relationship between the number of buds on a potato and its starch content; the relationship between the firmness of meat and the cooking time; the relationship between rotting/molding and ambient temperature and humidity; and the purity of water. When student C finished explaining the fifth idea, student B repeated that they had five candidate ideas and that they would like to hear the TA's comments on which experiment design was most feasible.

(1) Tutorial S01[1]

1	TA01:	*eto, gutaitekini kō::*
2		*kimitachi ni kimete hoshii no wa,*
3		*ja, tatoeba, kō:, e? nandarona,*
4		*kono ((points at the notes))*
5		*niku no yakikata toka,*
6		*dō yatte, katasa ga kawaru tte iu koto o*
7		*itte mashita ne?*
8→		*katasa tte dō yatte hyōka suru no ka,*
9→		*dō yatte shiraberu no ka.*
10	ST B:	((silence))
11	ST A:	((places his hand on his chin as though he is
12		thinking about something))
13	ST C:	((silence))
14	TA01:	*tatoeba sa, e:to,*
15		*kono* ((points at the notes))
16→		*banana no kurosa to tōdo to iu no ga,*
17→		*nanka kō: keiryōteki ni kō:*
18		*minna kyōtsū ninshiki to shite aru jan?*
19		*aru yo ne?*
20		*gainen, gainen to shite.*
21→	ST B:	*hai.*
22→	TA01:	*sūchiteki na mono toshite, dakara,*
23		*jissai ni tōdokei tte iu no ga aru kara.*
24	ST B:	*hai.* ((ST A & B show no reaction))

25 TA01: *de, ippō de,*
26 *niku no katasa tte*
27→ *dō yatte kimetara ii no?*
28→ *dō yatte kō hakattara ii?*
29 *sō yatte kangaeta toki ni*
30 ST B: *hai.*
31 TA01: *honto ni kō:, nante iu ka, nante iu ka na, kō:,*
32→ *hyōka shiyasui ka na teiryōteki ni.*
33 ST A: ((nodding gesture))
34 ST B: aa. ((looks at TA and nods))
35 ST C: ((nodding gesture))

(1) Tutorial S01 (Translated version)

1 TA01: Err, specifically, what I would like you to
2 think about to make a decision is, for example,
3 well, how can I say, like this ((points at the
4 notes)), how a different way of grilling meat
5 changes the firmness of meat,
6 you talked about the idea, right?
7 How do you evaluate the firmness of meat, or
8 how do you investigate it?
9 ST B: ((silence))
10 ST A: ((places his hand on his chin as though he is
11 thinking about something))
12 ST C: ((silence))
13 TA01: For example, err,
14 regarding the idea ((points at the notes))
15 on the relationship between peel brownness
16 and sweetness of bananas, we can use sugar
17 content metrically, and we know it as our
18 shared understanding, right?
19 You know it,
20 you know the concept, right?
21 ST B: Yes.
22 TA01: As numerical values, actually, we have
23 an instrument for measuring sugar content.
24 ST B: Yes. ((ST A & B show no reaction))
25 TA01: On the other hand,
26 how do you decide
27 the firmness of meat?

28		How do you measure it?
29		When you think about it.
30	ST B:	Yes.
31	TA01:	Really, how can I say, how can I say,
32		do you find it easy to measure the firmness of meat with a quantitative method?
33	ST B:	((nodding gesture))
34	ST A:	Yeah ((looks at TA and nods))
35	ST C:	((nodding gesture))

Although the students' attitude and their way of asking questions might not be unusual for first-year undergraduates, they asked TA01 questions as if they wanted him to decide their experiment. But instead of answering the students' questions directly, TA01 hesitatingly asked several questions to the students. For example, in line 8 TA01 asked the student *katasa tte dō yatte hyōka suru no ka* ('How do you evaluate the firmness of meat'), and in line 9 he also asked the students *dō yatte shiraberu no ka* ('how do you investigate it'). TA01 used the word *hyōka suru* ('evaluate') first, and then he complemented the question by using a different word *shiraberu* ('investigate'). Since the three students became silent—in a Japanese classroom setting, silence generally means "I do not know"—TA01 kept on providing an example of *banana no kurosa to tōdo* ('peel brownness and sweetness of bananas') as a typical *keiryōteki* ('metrical') investigation method as shown in lines 16 and 17. Then, because only student B answered *hai* ('yes') in spite of the effort TA01 made to confirm the students' understanding, TA01 provided another word, *sūchiteki* ('as numerical values'), in line 22, and said *jissai ni tōdokei tte iu no ga aru kara* ('actually, we have an instrument for measuring sugar content') in line 23. Again, only student B answered *hai* ('yes') while the other two students showed no reaction, but this time TA01 came back to the initial question regarding *niku no katasa* ('the firmness of meat'). In lines 27 and 28, he asked the students first *dō yatte kimetara ii no?* ('how do you decide the firmness of meat?') and then *dō yatte kō hakattara ii?* ('How do you measure it?'). In this sequence of questions, TA01 did not give explicit instructions to the students; instead, he suggested only implicitly how to investigate the firmness of meat by using the words *hyōka suru* ('evaluate') in line 8, *shiraberu* ('investigate') in line 9, *kimeru* ('decide') in line 27, and *hakaru* ('measure') in line 28. Similarly, TA01 used the words *keiryōteki* ('metrically') in line 17, *sūchiteki* ('as numeric values') in line 22, and *teiryōteki* ('quantitative') in line 32. All of these terms in Japanese refer in some way to quantity or quantification, with *teiryōteki* referring particularly to a fixed or determined quantity. TA01's way of giving advice on research design in this way clearly corresponds to Nakaya's assertion that one of the features of science is the concept of quantification (1958, p. 3). What TA01 actually did in this passage is explain how to investigate a certain natural phenomenon in a constant way using numeric values.

After that, TA01 gave further advice on how to generate new ideas, how to utilize background papers, how to try to be original, how to understand the concept of prediction, and how to develop a discussion. Then he concluded by telling the students to consider for themselves which research design was most feasible based on the perspectives he had introduced to them. When he was asked by the researchers to comment on the tutorial after the students had left the Lab, TA01 said what he always told students in tutorials was the same as what he had been told by his supervisor.

Tutorial S04: *Jōken ga sorotte iru* and *kyakkanteki na sūchi daseru*

TA04 was a graduate student in a master's degree program in a biology-related field and had two months of experience tutoring at the time of observation. Although his experience as a teaching assistant was short, he had taken ALESS when he was a first-year undergraduate. In the questionnaire filled out by TAs after tutorials, TA04 mentioned that he was interested in the ALESS program more now than when he had been a student in the class. When student D, a first-year science undergraduate taking the ALESS class, came to the Lab one afternoon, a couple of tutorials were taking place in the room but the Lab was not busy compared to lunch hour sessions. Student D was introduced to TA04 by the Lab manager, and they sat around a small round table face to face. TA04 asked in a friendly manner for the student to tell him his question. The student D hesitantly talked in a small voice about his idea of dropping an object from a high place onto sand. The student D did not ask a question directly, but it seemed that he wanted some advice on his experiment idea.

(2) Tutorial S04:01

1	TA04:	*betsu ni (.) sono (.) ona,*
2→		*nankai ka jikken suru wake ja nai desu ka*
3→		*sono toki ni [kakujitsu ni onaji suna,*
4	ST D:	*[hai.*
5→	TA04:	*onaji ryō o tsukatte ite*
6		*de (.)[de (.)*
7	ST D:	*[hai.*
8→	TA04:	*jibun de mite taira ni natte iru*
9→		*tte iu fū ni shitere ba,*
10→		*sore wa sono kaku jikken goto ni*
11→		*jōken wa sorotte iru to omou shi.*
12	ST D:	((nodding gesture))
13→	TA04:	*kaku jikken goto ni jōken ga sorotte iru*
14→		*tte iu koto ga hoshō dekiru*
15→		*to iu no de are ba*
16		(0.2)
17		*mattaku mondai nai to omou node.*
18		*betsu ni (ii desu).*

(2) Tutorial S04:01 (Translated version)

1	TA04:	Well, you're going to perform
2		the experiment several times, aren't you?
3		At that time,
4		if you can use exactly the same sand,
5	ST D:	Yes.
6	TA04:	with the same amount,
7		and, and,
8	ST D:	Yes.
9	TA04:	if you can check the flatness visually,
10		I think you can say that
11		the experimental conditions will be the same.
12	ST D:	((nodding gesture))
13	TA04:	As long as you can prove that
14		the conditions for all the experiments
15		are the same,

16 (0.2)
17 I think it should be all right.
18 It should be (no problem).

When student D said hesitantly that he was wondering how to fill a container with sand, TA04 replied *nankai ka jikken suru wake ja nai desu ka* ('you're going to perform the experiment several times, aren't you?') as shown in line 2. Then, TA04 added *sono toki ni kakujitsu ni onaji suna, onaji ryō o tsukatte ite, jibun de mite taira ni natte iru tte iu fū ni shitere ba* ('if you can use exactly the same sand, with the same amount, if you can check the flatness visually'), as shown in lines 2, 3, 5, 8, and 9. In doing so, he implicitly suggested that the student perform the experiment several times using the same amount of the same sand, and he did this by asking for confirmation as if the student already knew what he was supposed to do. In addition, judging from TA04's utterance *sore wa sono kaku jikken goto ni jōken wa sorotte iru to omou shi* ('I think you can say that the experimental conditions will be the same') in lines 10 and 11, it can also be assumed that he implicitly told the student how to maintain the same conditions. Similarly, in lines 13 to 15, in order to respond to the student's question on how to fill a container with sand, TA04 said *kaku jikken goto ni jōken ga sorotte iru tte iu koto ga hoshō dekiru to iu no de are ba* ('As long as you can prove that the conditions for all the experiments are the same'). Again, TA04 emphasized consistency in the experimental conditions by repeating the phrase *jōken ga sorotte iru* ('the conditions for all the experiments are the same'), suggesting that the student make sure to keep the conditions consistent in all the experiments. In this case, however, TA04 did not provide only simple ideas or tips on how to perform experiment. In addition, he not only gave ideas on how to perform experiment but also suggested a scientific method for extracting an observable phenomenon.

This focus is even more apparent in the next extract, Tutorial S04:02. Here, the topic has changed to the student's next question. The student explained his idea of dropping objects with different densities from a high place, measuring the depth of the dent made by each object, and taking pictures of how the sand was disturbed by the different objects.

(3) Tutorial S04:02

1	TA04:	*aa:::, naruhodo ne.*
2		*aa, sore wa*
3		(1.2)
4→		*ii desu ne.*
5→		*fukasa tte iu no wa*
6→		*sugoi teiryōteki ni hakareru kara*
7→		*sore wa mo kyakkanteki na sūchi daseru shi.*
8		*sore to hosokuteki ni,*
9		*to iu ka,*
10		*sore to wa mata betsu ni,*
11→		*sono jibun no kansatsu shita yōsu to shite,*
12		*kore ni wa kō iu tokuchō ga atta*
13		*mitai na koto o*
14		*tatoeba pēpā ni kaku wake desu yo ne?*

(3) Tutorial S04:02 (Translated version)

1	TA04:	Ah::, I see.
2		Ah, that is
3		(1.2)
4		a good idea.
5		Because the depth is very quantitatively
6		measurable, it makes it possible
7		to obtain objective numerical values.
8		Additionally, to complement the results,
9		or I should say,
10		separately from the quantitative results,
11		as a phenomenon observed by you,
12		you might like to write about the features of
13		the experiments with different objects,
14		perhaps, in your paper, right?

In line 4, TA04 said *ii desu ne* ('a good idea') for the student's idea of paying attention to the depth of the impact craters. In line 6, TA04 added the reason, saying *sugoi teiryōteki ni hakareru kara* ('very quantitatively measurable'), meaning that paying attention to the depth was good because it was quantifiable. Similarly to TA01's utterances in the extract from Tutorial S01, TA04 used the words *hakaru* ('measure') and *teiryōteki* ('quantitative'), which stand for one of the core concepts of science. Additionally, in line

7, he said *sore wa mo kyakkanteki na sūchi daseru shi* ('it makes it possible to obtain objective numerical values'). TA04's use of the word *daseru* ('able to extract; obtain') suggested that the student was supposed to extract numeric values from natural phenomena. Furthermore, TA04 concluded that *fukasa tte iu no wa sugoi teiryōteki ni hakareru kara sore wa mo kyakkanteki na sūchi daseru shi* ('Because the depth is very quantitatively measurable, it makes it possible to obtain objective numerical values'), that is, he implied that measuring something quantitatively can yield numerical values to express observed phenomena. What he told the student is thus consistent with the concept suggested by Nakaya that the basis of science is quantification (Nakaya, 1958, p. 40). What TA04 told the student can therefore be said to be the scientific method itself. Moreover, in line 11, TA04 said *sono jibun no kansatsu shita yōsu to shite* ('as a phenomenon observed by you'). TA04 used the word *jibun* ('you'), suggesting subjectivity, and contrasted it with the idea of *kyakkanteki na sūchi* ('objective numerical values') mentioned earlier. By doing so, TA04 successfully made a distinction between quantitative and qualitative methods.

Tutorial S09: *Kō yatte…*

TA09 was a graduate student in a master's program in the social sciences and had been a tutor for one year. TA09 was good at taking care of novice TAs, and in fact he mentioned on the TA questionnaire that he enjoyed talking with first-year undergraduates. Student E, a first-year science undergraduate taking the ALESS class, came to the Lab for advice on how to conduct his experiment and which instruments to use. Access to instruments and techniques for using them are frequent topics in tutorials at the Lab because they are essential for performing experiments. Student E was initially introduced to another science TA, who was a novice. In the middle of the tutorial, TA09, who had longer experience at the Lab, was called to explain how to use an old-style pipette instead of the novice TA. TA09, who had an old-style pipette in his right hand, walked to a sink cabinet and demonstrated how to use the pipette using tap water.

(4) Tutorial S09

1 TA09: *e::tto, ue o (.) mazu, ue o kaihō shite (.)*

→		*kō yatte mazete*
		de, shita o akete
		((demonstrates how to do it to the student))
	ST E:	((looks at the demonstration))
→	TA09:	*kō:: totte*
		((takes up water in the beaker using the
		pipette))
		soshitara (.) mippei sarete iru n de
		kō iu fū ni tamotare te iru kanji nande
		ato wa mata
		sakki wa
→		*kotchi o akete kō*
	ST E:	*aa::*
→	TA09:	*kō yatte saigo kō (.) mo ikkai*
	ST E:	*aa::*
	TA09:	*chotto umaku ikanakatta na*
		saigo (.) saigo no hito oshi ga
→		*saki mitemasu?*
		((shows the last push again))
	ST E:	*naruhodo.*
	TA09:	*kō iu katachi de*
→		*ja chotto yatte mite*
		((gives the pipette to the student))
	ST E:	((Tries to take out water from the beaker
		using the pipette))
→	TA09:	*ichiban ue made irecha dame*
	ST E:	*aa:::*
	TA09:	*gyaku ni gomu ni ima haitte iru n dakedo*
		tsukaenaku naru kara
	ST E:	*aa:::*
	TA09:	*tatoeba kore ga ryūsan yōeki toka*
		so iu no datta ra
	ST E:	*so desu nē*
		((Tries to take out water from the beaker
		using the pipette))
	TA09:	*saigo chanto oshite yatta ra*
	ST E:	*aa:: naruhodo.*
→	TA09:	*ja mo ikkai itte mimashō ka*
→	ST E:	*hi hi hh*

(4) Tutorial S09 (translated version)

TA09: Well, release the top part first of all,
and then mix it in this way.
And release the bottom part.
((demonstrates how to do it to the student))
US09: ((looks at the demonstration))
TA09: Take it up in this way.
((takes up water in the beaker using the
pipette))
And this seals in the water
and keeps it this way.
After that
(first of all)
open this part in this way.
ST E: Ah ha::
TA09: Do it this way, and lastly,
do it like this, again
ST E: Ah ha::
TA09: I was not able to do it well,
the last, the last push.
Are you looking at the tip of the pipette?
((shows the last push again))
ST E: Yes, I got it.
TA09: OK, have a try.
((gives the pipette to the student))
ST E: ((Tries to take up water from the beaker
using the pipette))
TA09: Do not let water go up to the top.
ST E: Ah::
TA09: The water is now running up to the rubber part,
and this makes it impossible to use the pipette.
ST E: Ah::
TA09: For example, if this were sulfuric acid or
something like that.
ST E: Yeahh
((Tries to take up water from the beaker using
the pipette))
TA09: Push it properly until the end.
ST E: Ah:: I see.
TA09: OK, let's do it again.

40 ST E: He-he hh

While TA09 demonstrated how to use a pipette using tap water, student E stood by the TA watching the demonstration. In lines 2, 6, 13, and 15, the TA frequently used the demonstrative word *kō* ('this') to mean 'in this way'. As in the case with the study by Yanagimachi (2006), in which a professor tried to pass down his technique to an international student, TA09 taught a technique that he thought important by demonstration, not only by words. Additionally, in line 19, TA09 said *saki mite masu?* ('Are you looking at the tip of the pipette?') to attract the student's attention to the technique. Instead of explaining how to do it verbally, he requested the student to look closely at the tip of the pipette. In this way, the instructions on how to use an instrument involved mostly actions.

Furthermore, TA09 sometimes gave instructions somewhat firmly. In line 23, for example, he said *ja chotto yatte mite* ('OK, have a try') to let the student practice by himself. In line 27, TA09 said *ichiban ue made irecha dame* ('Do not let water go up to the top'), and in line 39, TA09 said *ja mo ikkai itte mimashō ka* ('OK, let's do it again'), and had the student practice repeatedly in order to make sure the student understood how to use it. Hearing the instruction, as shown in line 40, the student let out a wry laugh *hi hi hh* ('He-he hh'), for this method of tutoring might have seemed a little bit too much to him.

Overall, such advice accompanied by actions is given in a more directive way than those for the experimental ideas in S01 and S04. This may be because instructions accompanied by actions can be given in a more apparent and explicit way than verbal instructions, but it may also be because using an instrument consistently can be crucial for obtaining consistent results. The pipette, for example, is an instrument for taking up a certain amount of liquid, and there are many types of pipettes with different capacities. Being able to use a pipette properly makes it possible to quantify phenomena consistently.

Discussion

The extracts of the three tutorials illustrate how interactions were conducted between the science TAs and the students. On a superficial level, such conversations in the ALESS Lab can be categorized into how to design scientific research and how to perform experiments, with Tutorial S01 focusing on the research design and S04 and S09 on the experiment. Developing ideas for research design and using instruments for experiments seem to be different stages of a scientific writing project, but actually, all of these activities lead to the same issue: how to perceive reality. In Tutorial S01, for example, the major consultation topic is how to investigate a certain natural phenomenon using a consistent method and numerical values. The main topic in tutorial S04 is how to determine a quantifiable phenomenon. The featured extract from tutorial S09 is advice on how to use a pipette, that is, a procedure to determine a certain natural phenomenon physically.

Although the three tutors conducted their tutorials in different ways, they all exhibited a common goal: to quantify observed phenomena for reproducibility. Through such tutorials, the ALESS Lab provides an environment for students to learn one of the core concepts of science. Thus, although the Lab is a support facility for an English-language program, the focus of the tutorials at the Lab is not language but the scientific process itself, and interaction with science TAs provides first-year science undergraduates with admission to a scientific community.

This raises the question, however, of the significance of teaching scientific concepts in an English program. Some may argue that this is the proper role of specialized courses and laboratories. But the educational significance of this kind of learning environment can be seen in how the sequence of scientific procedures relates to writing. By actually engaging in the design of an experiment aimed at elucidating physical phenomena, the students come to understand better the context in which they need to use specific rhetorical rules, such as the IMRaD style, avoidance of subjectivity, voices, and tense. They realize that these rhetorical rules reflect a scientific method and a scientific way of behaving and thinking. As Kuhn suggested (1970, p. 191), they can learn the scientific language together with concrete examples of how it functions in use. They become able to understand what, for example, the word *teiryōteki* means both rhetorically and in practice. Additionally, through designing experiments, discussing with peers, performing experiments, and analyzing the results, they learn just how much time and labor are required to write a single paper. Last but not least, they learn experientially what should be included in a scientific paper as findings and how to do that in English. Thus, learning scientific writing is synonymous with learning the entire process of describing a procedure to extract a certain reproducible phenomenon from nature.

A program for English language education, even when training science students, is usually considered to be an outsider to any scientific community. This may be due partly to the gaps between the cultures and customs of the humanities and the natural sciences. However, as one must participate in multiple communities in order to master—or to be counted as having mastered—the practices of a certain community (Lemke, 1997, p. 43), learning environments for science students should not be exclusive to specialized courses and laboratories. Scientific writing is a means for sending a message to a scientific community that a certain natural phenomenon has been extracted reproducibly under certain conditions. With English now the de-facto common language of the physical sciences, English-language education should help science students acquire more than just linguistic and rhetorical skills. As shown by the tutorials in the ALESS Lab, English-language education for science students need no longer be an outsider to the scientific community. Instead, it can be a subgroup that shares a common purpose with it—training future scientists so that they can share their findings with the world through English.

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Note

1. Transcribing has been done in the Jeffersonian system (Jefferson, 2004).

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Appendix A: Transcription conventions

(0.5)	Time gap
(.)	Pause
[	Overlap
hh	Breathing out
((gesture))	Non-verbal activity
:	Stretched sound
(guess)	The transcriber’s guess at an unclear utterance
?	Rising inflection
→	Part to be discussed in the analysis