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Learning about Science through Language

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Abstract

When beginning their academic careers, science students are often facing difficulties with the communication of their findings using the genre-specific features of scientific English. This difficulty is even compounded for students using English as a foreign language.
Falsifiabilty is a character of science that is often overlooked by Japanese high schools due to scientific curricula at that level emphasizing the memorization of facts and the demonstration of pre-established findings. This lack of awareness, comforted by the international publication skewed towards positive results, is reflected in student reports as they often overstate findings reported in scientific publications and classify negative results as reflective of poorly conducted experimental procedures.
This study conducted at the University of Tokyo focuses on the use of hedging in scientific reports written in English by Japanese first year undergraduates. Students entering the university as science majors are all required to take an English language class specifically designed to address scientific writing (Active Learning of English for Science Students). This course is ultimately sanctioned by a report that students have to write using data obtained through an experiment of their own design.
Our findings show that focusing on the linguistic aspects of hedging helps students re-assessing the falsifiability of published findings as well as locating more accurately their own work within the existing body of scientific findings. We propose that exposing students to various samples of scientific writing as well as guiding them through the examination of genre-specific hedges could benefit even native speakers who are internalizing the concepts of falsifiability and the experiential nature of science.

1. Introduction

Specialized English courses categorized as English for Specific Purposes (ESP) have multiplied over the past 40 years in order to provide students with a concrete context in which to use the language [1]. ESP courses rely on discipline-specific materials to allow students to acquire communication skills - either in writing or in speaking - that will be most appropriate for their academic activities. Using English for academic publication in the sciences requires the mastery of numerous rules that are specific to the genre and these rules are often difficult for nonnative speakers to acquire due to their lack of exposure to scientific vocabulary or syntax [2-4].
In 2008, the University of Tokyo launched its own ESP course tailored for Japanese first-year undergraduate students majoring in science. This English language program called ALESS (Active Learning of English for Science Students) is unique in the sense that, to extent of our knowledge, it is the only existing English course that requires students to complete an actual scientific experiment of their own design in order to use the data obtained for writing a report formatted like a typical journal paper. This innovative program aims at both introducing students to the rules of academic writing that they will have to follow when submitting a paper for publication, and presenting various aspects of scientific research that are not usually covered by curricula in high schools.
Among such aspects is the notion of falsifiability, or the idea that a hypothesis is judged scientific if it can be proven wrong. The notion was introduced by Popper in the 1950's and led to generalizing the idea that scientific activity consists of questioning hypotheses rather than proving them, thus placing a clear boundary to the acquisition of new knowledge through inductive processes [5]. Falsifiability thus posited a radical view of science, where a scientific theory could never be verified definitely but rather only accepted as long as they have not been falsified. However, such a view is often at odds with what students believe science to be, that is, a consistent collection of objective facts that ultimately uncover the reality of natural laws. This belief is often supported by the traditional teaching of science in high school based on verification-type activities [6]. Such teaching is more akin to confirm theories and foster dogmatic thinking than encouraging the development of a critical and scientific mindset [7].
Scientists have since then argued that popperian falsifiability, despite being a necessary element of what makes a theory scientific, is not sufficient to characterize it because scientists generate theories within existing paradigms that make researchers 'expect' particular outcomes [8]. This paper aims to

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demonstrate that attracting students' attention to the language used in scientific communication can help them improving their understanding about scientific inquiry and scientific methodologies. Particularly, we argue that engaging students in peer review activities focusing on the differential use of hedging features in their introduction and discussion sections can allow them to develop their awareness about falsifiability in scientific theories, the importance of probabilistic approaches to observations and inductive reasoning in science.

2. Methodology

2.1 Participants

This study is using 20 writing samples that were selected randomly from final assignments provided by ALESS students over one 13-week semester between April 1st 2015 and July 31st 2015. These 6-10 page reports contribute to half of the final grade that students obtain for that course. All ALESS students were majoring in science and studied English for a minimum of 6 years through grammar-translation methods. In the classroom, they experienced the successive steps of the scientific methodology, from proposing a hypothesis, designing a protocol to test that hypothesis, treating data and drawing reasonable interpretations from them. In-class activities focused on the writing of students' papers and consisted of exercises targeting the rules of academic writing through guided reading, collaborative activities, peer feedback and teacher feedback.

2.2 Samples

For each of the 20 reports that were considered for this study, the use of hedges was examined in the Introduction and the Discussion sections. Each report was considered as an individual case study in a broader parallel case study [9]. Each statement in the Introduction and the Discussion was examined for the use of appropriate hedging while referring to either past references or the student's own experimental results.

2.3 Analysis

The qualitative analysis followed in this study was inspired by the guided theory [10] that posits that each statement should be considered and evaluated in light of the existing theory. In the present case, we referred to the hedging taxonomy proposed by Hyland [11] that separates factive and non-factive (from now on hedged) statements. Hedged statements are further divided into content-oriented - where the level of confidence expressed describes accurately the observations - and reader-oriented - where the reader is given the opportunity to choose and evaluate options - statements. In each case-study, the use of hedges (or lack thereof) was examined in connection with either the experimental work produced by the student or the references cited, in order to provide an explanation for the patterns observed in students' use of hedging.

3. Results

From the selected pool of 20 student papers, our contextual examination showed that students tend to follow similar trends when using hedging [12] in their Introductions and Discussions as they generally overstate scientific findings from previous published research and understate their own results.

Over-generalizations were associated with clear citations or not, and are written usually with the present tense that marks general truths [13]. However, some students accurately indicated experimental findings through the use of the past tense.

On the other hand, toned-down statements associated to students' findings pertained to experimental inaccuracies, such as the lack of replicates and their inability to control some parameters, but also the uncertainty associated with their interpretations. A majority of students introduced their findings using the past tense despite some of them over-generalizing their results or mixing hedged with factive statements.

In addition, students were also capable of identifying overstated propositions in their classmates' papers during guided peer review exercises in class. Peer reviews were followed by in-class discussions where the students displayed the ability to critically analyze their peers' experiments.

The fact that student hedged more their statements in their Discussions than in their Introductions suggests that they associated the reporting of past findings and the reporting of their own findings with different levels of uncertainty. This illustrates the validity gap that exists in students' opinion between the information they acquired through published references and that obtained through their own experimental procedure. The fact supports the idea that the lack of hedging in the introduction is not so much related to a reduced lexical library but rather a conscious choice.

4. Discussion

The fact that students were able to critically comment on the level of hedging associated to their peers' findings suggests that lack of hedging in their texts were not associated to a lack of critical thinking or the maintenance of 'face' proposed by Gosden [14].

Our examination thus suggests that apprentice writers in Japan not only face lexical difficulties related to their lack of exposure to hedges used in science, which are characteristic of second language learners [15], but also problems in negotiating accurately the meaning associated to their claims. The latter problem is more generally an issue with all apprentice writers, even native speakers [16].

The representation of uncertainty is important in scientific communication as researchers need to emphasize the credibility of their findings while at the same time ensuring that these claims remain acceptable to their community [11]. Therefore, it is often difficult for apprentice scientists to detect accurately the level of confidence associated to scientific claims. The Japanese students who participated in this study faced similar difficulties and tended to perceive published findings as "proven" or "validated", leading to statements lacking hedging. When confronted to the observation that the referenced findings were hedged, just like they hedged their own findings, students could propose more appropriate forms for their statements.

In conclusion, guiding apprentice science writers through the rules of hedging can allow them to not only reflect on the credibility associated with their own claims but also to locate these findings more appropriately within the existing body of literature.

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