Investigation of Process Oriented Guided Inquiry Learning as a Framework for Teaching Science-focused English Courses at a Japanese University

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Abstract

Previous research indicates that inquiry-based learning is beneficial for English-language learners in content courses. Process Oriented Guided Inquiry Learning (POGIL) is a student-centered, team-focused framework widely used in the United States at the high school and university levels for teaching science. All POGIL activities follow a 3-phase learning cycle and are often organized such that students are treated as learners of the language of science. Published research investigating the effectiveness of POGIL has been conducted primarily at the undergraduate level using material written in English with no distinction regarding the English level of the students. However, anecdotal evidence indicates that POGIL benefits English-language learners in content courses, even when they are mixed with native speakers. The goal of this study was to investigate student assessment of their learning gains when POGIL was used to teach a molecular biology-focused English course at a Japanese university. All students in the course were English-language learners. Students were either first- or second-year enrollees and approximately 66% were science-track students and 33% were humanities-track students. Results from this study show that students had a positive attitude toward the POGIL method and felt that the activity structure furthered their content knowledge as well as improved their English language skills.

Keywords: POGIL, content-based language learning, student-centered science instruction

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Introduction

Previous research indicates that inquiry-based learning is beneficial for English-language learners in content courses (Adams, Jessup, Criswell, Weaver-High, & Rushton, 2015). Process Oriented Guided Inquiry Learning is a student-centered, team focused framework widely used in U.S. science curricula at the secondary and tertiary level. For a general overview of POGIL, readers are encouraged to visit the POGIL Project's website (https://pogil.org/). For science teachers who wish to switch to student-centered teaching but lack experience and time to create material, POGIL is an attractive option backed by a supportive community and abundant peer-reviewed teaching material.

A recent review of the literature supporting the effectiveness of POGIL can be found in Chapter 5 of *POGIL: An Introduction to Process Oriented Guided Inquiry Learning for Those Who Wish to Empower Learners* (Simonson, 2019). Science courses taught using the POGIL framework showed improved student outcomes such as increased exam scores and decreased withdrawal rates. In the reviewed literature, the POGIL material used was provided in English. While the investigations were conducted with no distinction regarding the English level of the students, anecdotal evidence indicates that POGIL benefits English-language learners (ELLs) in content courses, even when mixed with native speakers.

Guillaud and Ruppel (Simonson, 2019, chapter 12, table 12.1) have demonstrated that principles of the POGIL framework can be applied to the five standards designated by the American Council on Teaching Foreign Languages. Moreover, POGIL has been implemented in second language learning, for example German (Johnson, 2011) and French (Simonson, 2019, chapter 12). However, POGIL has not been investigated as a method of teaching in science content-based English courses for ELLs in Japan.

Learning science, as with any academic field, requires acquisition of new vocabulary and phrases. Previous research indicates that the amount of new vocabulary encountered in a science textbook can exceed the recommendation for middle school and high school foreign language courses (Groves, 1995; Yager, 1983). The POGIL approach, which is primarily implemented for novice learners, does not assume the learner has acquired all the content-obligatory vocabulary. On the contrary, well-designed POGIL activities provide learners with vocabulary and phrases in a context richer manner, thereby treating the science student as a language learner (Ellinger, 2019)

The aim of the project described in this paper was to investigate student attitude toward and self-assessment of learning gains when published learning materials built around the POGIL framework were used in a science content-based English course for ELLs at a university in Japan.

Classroom Context and Participants

Participants were first- and second-year students at a Japanese university. The course was a 13-week thematic course in the university's intermediate English series. Students meet once per week for 105 minutes. Courses in this series are compulsory, content-based, and the theme is chosen by the instructor. Although students may

indicate a preference for certain topics, they are not guaranteed their first choice (this fact was not known by the instructor prior to design of the course).

A total of 33 students were officially enrolled in and finished the course. The study was approved by the university's Committee on Ethics of Experimental Research on Human Subjects. Participation in the study was voluntary and consent was received from 32 students.

Students demonstrated a wide range of spoken English fluency as determined by an in-house system of evaluation. Japanese was the native language for 30 of the participants, and for the remaining two Chinese was the native language. Of the surveyed students, 23 were science-track and 9 were humanities-track; 24 were male and 8 were female.

The instructor of the course holds a Bachelor's in biochemistry and molecular biology and a Ph.D. in biochemistry. He has considerable experience teaching and mentoring students in these fields. At the time of teaching the course, the instructor had 3 years of experience teaching scientific writing and academic presentation for ELLs but holds no formal training in language teaching. Although, he has extensive experience as a language learner having studied French for more than 10 years and Japanese for more than 5 years.

Course Structure and Learning Materials

The theme of molecular biology was chosen based on interest as expressed by students in the instructor's other courses. However, as mentioned above, during course design the instructor was unaware that actual enrollment in the course was dependent on a pseudo-lottery-based system. Therefore, course design did not anticipate the various demographics of the eventual course enrollees.

A survey of the enrolled students indicated that most had not completed much coursework in biology, regardless of whether they were science- or humanities-track. For example, multiple students indicated that they had not enrolled in a biology course since middle school. Therefore, the theme was deemed reasonable because many issues that appear in daily life, such as genetic diseases or genetically modified organisms, are rooted in molecular biology. A basic understanding of the topic is useful for all students.

The course was divided into multiple units by topic, and in general each unit lasted two weeks. During the first week, a POGIL activity was used to introduce students to the unit's topic. The POGIL activity served as an entry point for both the content and vocabulary. During the second week, students engaged in discussions using previously published material such as case studies from HHMI BioInteractive (www.biointeractive.org)[1].

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[1] The non-POGIL activities will not be discussed further, but as an example, readers are encouraged to check activities associated with the short film *Got Lactase? The Co-evolution of Genes and Culture*.

The POGIL materials used were taken from *POGIL Activities for High School Biology* (Trout, 2012b) and *POGIL Activities for AP Biology* (Trout, 2012a). The topics covered in the class are listed in Table 1. These texts were chosen because they have passed through rigorous testing and revision before publication. The materials were use in their original form and not modified for an ELL context.

Table 1. List of topics covered in the course.
The topics were presented in the order shown.

Topic	Source of activity
Biological Molecules	*POGIL Activities for High School Biology*
Protein Structure	*POGIL Activities for AP Biology*
Prokaryotic and Eukaryotic Cells	*POGIL Activities for High School Biology*
DNA Structure and Replication	*POGIL Activities for High School Biology*
Transcription	*POGIL Activities for AP Biology*
Translation	*POGIL Activities for AP Biology*
Genetic Mutations	*POGIL Activities for AP Biology*

Assessment of Student Attitude and Learning

At the end of the semester, students were asked to assess their learning gains. The survey administered was designed following the guidelines of the Student Assessment of their Learning Gains (SALG) framework (Seymour, Wiese, Hunter, & Daffinrud, 2000). Student answers were based on a 5-point Likert scale.

After each POGIL lesson, students were surveyed about their perception of the difficulty of English used in the activity. Student answers were based on a 5-point Likert scale.

Results and Discussion

The aim of this investigation was to gauge student attitude and self-assessed learning gains when published POGIL materials were used as teaching material in a science-based content-driven English course for ELLs.

Students felt that the structure of POGIL activities was helpful for both learning English and gaining scientific knowledge (Figure 1). Activities built around the POGIL framework are carefully structured to follow a 3-phase learning cycle: Exploration -> Concept or Term Invention -> Application. A notable point is that questions generally become more complex as students advance through each phase. As content knowledge and vocabulary are built during the first two phases, questions in the Application phase can be answered by drawing on the information that was previously encountered.

Teamwork is an important component of POGIL activities, and students felt that working in a team was helpful for both learning English and gaining scientific knowledge (Figure 1). In the context of ELLs, teamwork is important because it

provides a setting to improve oral communication skills, which is one of the process skills that POGIL is intended to help develop.
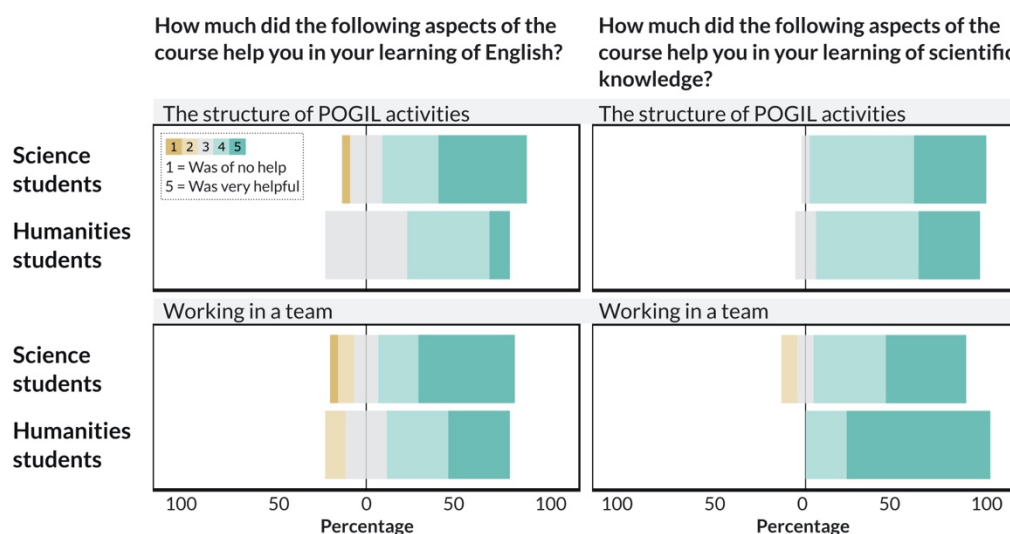

Figure 1. Students' assessment of the structure of POGIL activities and teamwork with regards to gains in English and scientific knowledge.

Students felt that they gained an understanding of various subtopics within molecular biology (Figure 2). Quiz scores (data not presented) indicated that students understood the content and could describe some details in English. However, the quizzes were short, mostly multiple-choice, and when writing was required the output was usually one or two sentences. Therefore, a more thorough investigation including longer writing assignments or short oral reports might help elucidate student gains, especially with regards to English.
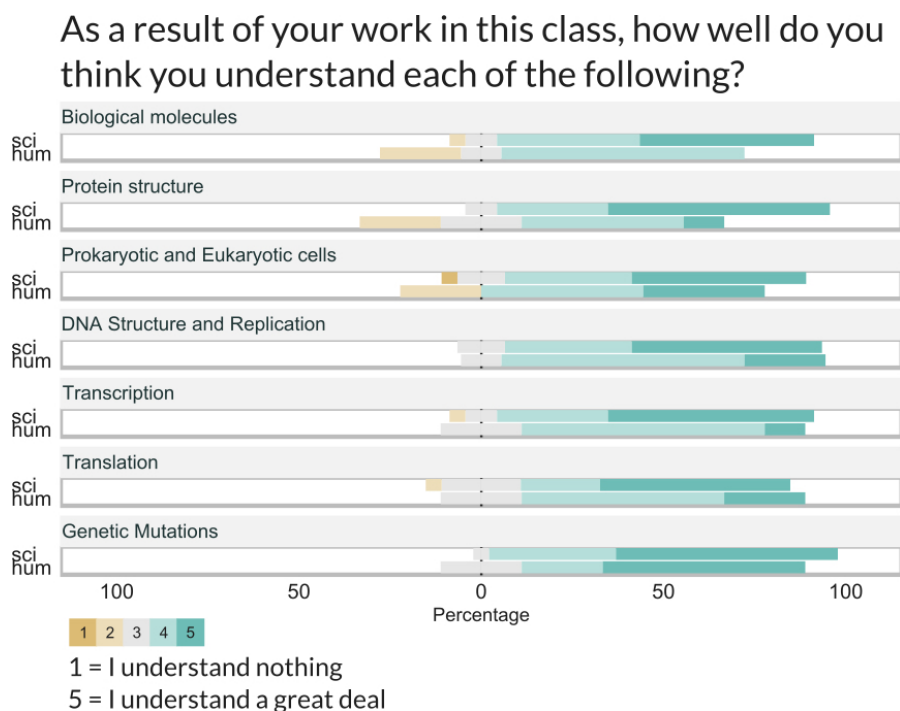

Figure 2. Students' assessment of their learning gains in unit of the course (sci = science students, hum = humanities students).

Students feeling about the difficulty of English varied by topic and humanities students generally found the English to be more difficult (Figure 3). This study was conducted using previously published POGIL materials and applied to an ELL context. The material was used in its original form but may need adjustment for an ELL context to improve its effectiveness. Furthermore, as mentioned above, a more detailed method to evaluate acquisition of English is required, such as writing assignments or oral reports. Additionally, audio or video recording of students' interactions during class could help identify other English production hurdles.
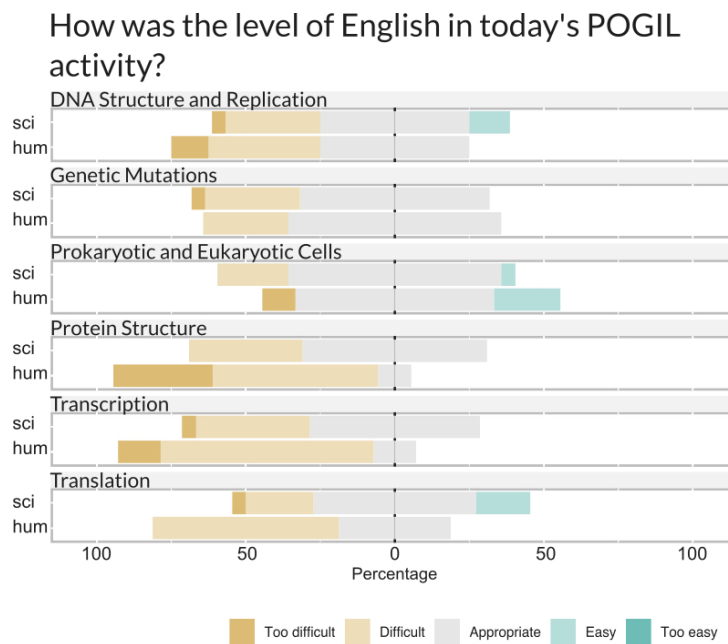

Figure 3. Students' assessment of English difficulty for each POGIL lesson (sci = science students, hum = humanities students).

As mentioned above, enrollment in the course is determined by a pseudo-lottery system. While enrollment of humanities-track students in the course was unexpected, the overall positive response is encouraging. In considering a future investigation, the humanities-track students could provide a good control against enrolled science-track students. Another point to consider is that second year science-track students enrolled in the course had more prior exposure to the scientific content of the course through lectures conducted in Japanese during their first year, which could lead to lower cognitive load consequently affecting English acquisition.

Acknowledgements

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