Abstract
Attempts to teach subject courses in English have become more widespread in Japanese universities. Methods such as Content and Language Integrated Learning (CLIL) is sometimes used to educate students in subject knowledge as well as English language. However, such practices hardly exist in Japanese technical colleges, where students are educated in vocational mechanical and engineering subjects. In view of the fact that technical colleges supply workers and engineers to rapidly globalizing technical fields, it is important for technical colleges to educate students to gain specialist knowledge and communication skills in English and Japanese. This paper reports one such attempt at a Japanese private technical college, where science courses are taught in English. The purpose of this paper is to report results from a research designed to gauge how much science learning was achieved in English-medium subject courses and whether English was a barrier in learning such subjects. We compared grades of 112 first year students who took English-medium courses and Japanese-medium courses in academic year 2016-17. We also analyzed course feedbacks and project assignments of the students. The results show that overall grade average of students in English-medium classes and Japanese-medium classes did not differ significantly. However, academically lower achievers may find English-medium classes more challenging. The grades and feedbacks of individual students indicate that students can gain sufficient subject course knowledge and technical abilities from English-medium courses. Research limitations do exist, but the results suggest the possibilities of educating subject courses to technical college students in English.

Keywords: STEM Education Active Learning English for Specific Purpose (ESP) Multicultural education Technical College
Introduction

In the 21st century, STEM and English form two pillars of education. Ever since Judith Ramaley coined the word STEM to refer to the education of science, technology, engineering, and mathematics in 2001, the importance of STEM education has been recognized in the U.S. and other developed and developing countries. Japanese government has been emphasizing the importance of English education, and English medium language education has been introduced since the last Course of Study for upper secondary education. Even for Japanese Technical colleges, globalization is regarded to be essential, and the suggestions for Technical Colleges include special subject education taught in English (Committee of Research Supporters on Enriching Technical College Education, 2015). There are now a few study concerning STEM education of non-native English speakers (Hoffman, Zollman, 2016). However, as far as we know, there is no study about English medium special education in a Japanese Technical College. This paper focuses on physics and chemistry courses taught in English to year 1 students (15-16 years old), in a Japanese private technical college.

Background

In May 2016, Education Ministers of G7 countries met in Kurashiki, Japan, and reached consensus on “the education paradigm for the future” which they published as Kurashiki Declaration (MEXT, 2016). In the declaration, one of the areas they stressed is the importance of improving the “links between education/training and employment in a technology-intensive world” by promoting education and training in ICT and STEM fields. They also recognized the need for integrating STEM with “other fields including art and design to encourage flexible thinking, risk-taking, and creative problem solving.” In their declaration, such education has to be conducted with the awareness of globalized world and international interaction for students as well as teachers.

STEM education is taught in Japan in science stream of Technical High Schools, science stream of normal high schools, government designated Super Science High Schools, and technical colleges. Although STEM education in globalized society is emphasized, there is no report on STEM education in high school taught in English except for English science presentation skills, English lessons about scientific topic, and short overseas science programs. Even in a governmental report on Super Science High Schools, there is no mentioning of the practice or recommendation of teaching STEM in English.(MEXT, 2017)

Teaching science subjects in English has its own challenges. One of the challenges is emotional effects felt by non-native speaking students who are taught in English. A survey was conducted to investigate changes in positive and negative effects for English Learning for year 1 new students at Kanazawa Technical College (KTC). This survey measured 1) Emotional experience about English, 2) Self-esteem in English Class, and 3) Anxiety in English Classes (Shiotani, 2014). Shiotani found that

---

2 高等専門学校の充実に関する調査研究協力者会議, 2015
Ss of this survey were more anxious about English language education at the beginning of the year, and they had less self-esteem. Although the survey shows that the anxiety level was reduced by the end of the year for all students, degree of reduction was the smallest for electrical engineering department students.

Current Study

Institution

This research has been conducted at a private technical college, Kanazawa Technical College (KTC), where English medium education forms a part of its curriculum. KTC is a college of technology, which is a special kind of school in Japan that is different from technical colleges in other parts of the world. A college of technology provides graduates with an Associate’s degree upon graduation, but that degree also includes three years of high school education. Students who enter a college of technology usually do so upon completing junior high school. Literally translated from the Japanese, a college of technology is a “high specialty school,” and as such it offers a 5-year intensive study curriculum that integrates the general education of a high school with specialized technical training of a vocational school. These schools are accredited as institutions of higher education by Japan’s Ministry of Education (See Figure 1).

![Figure 1: Educational System at KTC](image1)

With its 517 Ss and 55 faculty members, KTC is run by a Board of Directors that jointly oversees the neighboring 4-year university and graduate school of Kanazawa Institute of Technology (KIT) (See Figure 2).
Figure 2: KTC Management

Teaching Method

English immersion science classes have been implemented for the Physics and Chemistry required courses at KTC from 2016-17. Physics and Chemistry I are required 2 credit-hour courses at KTC. They are taught by one Japanese and one non-Japanese teachers. The non-Japanese teacher is the main teacher when English is the vehicle language in the first two terms, then the Japanese teacher becomes the main teacher when Japanese is the vehicle language of the course in the following two terms (See Figure 3).

Figure 3: Year 2016-17 Physics and Chemistry I Flow

CLIL

In the first two terms, we used CLIL methodology to address the issue of teaching specific subject in English, as students need to be educated both in the subjects as well as the vehicle language. CLIL is useful in making teachers and students aware of the type of languages they need to focus on during each lesson. Coyle (2000, 2002) has divided language of instruction into the three distinct categories. They are Language of Learning, Language for Learning, and Language through Learning (See Figure 4).
In individual lessons, teachers distribute activity worksheets to lessen students’ anxiety about the vehicle language. The worksheets help students deal with language issues in separate categories one at a time. So, students learn new technical terms through a lesson taught by an interactive powerpoint presentation and simulation, use their limited English knowledge to link what they understood with what they read in their Japanese textbooks, and come up with a word-mapping, then integrate them together to deduce the main concept taught in the lesson (See Figure 5).

Apart from classroom instruction in English, Ss are required to create a poster in English. This is to give Ss opportunity to research and put their findings together in English, and give them a sense of achievement. So, before summer holiday, Ss are assigned to make A3 posters on the topics they found interesting, which were taught in chemistry lessons during spring term. Ss could create the poster either in English or
Japanese. Marking criteria were about punctuality, overall organization, clarity of images, and accuracy of language and information used (See Figure 6).

![Figure 6: Project Assignment](image)

**Research Objectives**

The objectives of this research is to see if the change of language of instruction, vehicle Language, affects students learning outcomes or not.

**Research Methodology**

This study analyses student grades, project markings, and student survey results about English-medium Physics and Chemistry courses, and compare the results with Physics and Chemistry courses taught in Japanese. Data was collected in 2016-2017 school year for year 1 students (112 Ss).

**1-Grade Analysis**

Four criteria are used for assessment, and they are divided as follows: 10% for attendance and attitude, 30% for class work and assignments, 10% for quizzes, and 50% for end of term exams.

**2-Project Marking Analysis**

Before summer holiday, Ss were assigned to make A3 posters to cover what they have thought of as interesting chemistry topics which they learned during the spring term. Ss were allowed to choose between English and Japanese, whichever the language they prefer to use. Teachers gave the choice of the language of the posters to the Ss. Marking criteria were about punctuality, overall organization, clarity of images, and
accuracy of language and information used, the choice of language was not a marking
criterion. Therefore, Ss chose the language of their posters without the fear of being
marked differently.

3- School Survey Result Analysis

KTC has been conducting school surveys to measure Ss’ satisfaction of individual
courses. In the survey, the questions F, G, H, I, J and K are Ss’ self-assessment
questions about the main topics covered in a course throughout the schoolyear. In
Physics and Chemistry courses the F, G, and H are question about topics taught in
English in the first half of the year, and questions I, J, and K are questions about
topics taught in Japanese in the second half of the year.

Results/Discussion

Grade Analysis

We compared Computer Department individual Ss total grades of the first 2 terms,
and the second 2 terms correlation was 0.80, suggesting that there is a positive
correlation between the performance on first and second halves. We ran a z-test on the
grades, P value was 0.35 which is more than the most commonly used P value of 0.05,
which means there is no significance between the grades in the both cases. That
suggests that changing the vehicle language did not affect the Ss’ grades (See Figure
7).

![Figure 7: Physics and Chemistry I Grades of Computer Department](image)

We compared Mechanical Department individual Ss total grades of the first 2 terms,
and the second 2 terms correlation was 0.89, suggesting that there is a positive
correlation between the performance on first and second halves. We ran a z-test on the
grades, P value was 0.08 which is more than the most commonly used P value of 0.05,
which means the grades were marginally significant. That suggests that changing the
vehicle language did not affect the Ss’ grades (See Figure 8).
We compared Electrical Department individual Ss total grades of the first 2 terms, and the second 2 terms correlation was 0.84, suggesting that there is a positive correlation between the performance on first and second halves. However, the z-test showed different results, P value was 0.01 which is less than the most commonly used P value of 0.05. There is a significance in the grades of the 2 halves (See Figure 9).

Although their overall average of the first half was above the average, Ss of Electrical Department seem to be affected to some extent by changing the vehicle language. One of the reasons could be the anxiety students feel about the vehicle language. As shown in Figure 10, the Electrical department students have the lowest average points of all subjects amongst all first year students in all terms. Also, as Shiotani (2015) showed, the degree of reduction in anxiety level of electrical department was the smallest, so anxiety could affect academically lower-level students more.
Project Marking

The objective of project assignment analysis is to see how many students have chosen English rather than Japanese when given the choice. Another aim is to measure if the quality of the posters were affected by the choice of the language. Divided by department, 79.2% of Computer Department Ss used English for their posters, and only one student (2.1%) used Japanese. The remaining 18.8 % did not submit any posters (See Figure 11).

At Mechanical Department, 59.2% of Ss used English for their posters, and 31.3% used Japanese. 9.4 % did not submit any posters (See Figure 12).
At Electrical Department, 40.6% of Ss used English for their posters, and 43.8% used Japanese. And, 15.6% did not submit any posters (See Figure 13).

Across the departments, a bigger percentage of Ss chose English (62.5%), and only 22.3% of Ss chose Japanese (See Figure 14).
The result of poster marking shows that English posters got slightly higher average score than Japanese posters. The average score of Japanese posters was 75.8, while that of English posters was 79.8 (even though one of the English poster had the mark of 20 points due to students’ misunderstanding of the poster topic.) (See Figure 15).

**School Survey**

The objective of the self-assessment questions in the school survey are two folds: 1) to clarify how Ss see the content taught to them in English, ESP, and 2) to find out whether Ss’ opinions of the lessons are affected by the vehicle language or the scientific topics.
As seen in Figure 16, there are actually students in Computer Department, who marked 0% (meaning that they did not understand anything about the topic) for topics taught in Japanese.

In Mechanical Department, language is not necessarily the determining factor for the percentages of Ss’ understanding of topics (See Figure 17).
In Electrical Department, Ss seem to be generally satisfied with topics of both languages. 19.4% of Ss marked question G to be fully understood, that was a question about a topic taught in English, that suggests language did not intervene the Ss understanding of topics. (See Figure 18).

In All Departments, the response to all questions regardless the vehicle language change had a close pattern. In general, the majority of Ss marked more than 60 % understanding of topics which supports the idea that language did not affect Ss’ understanding of topics (See Figure 19).
Vehicle language did not affect students learning outcomes in departments with high and medium academic achievers. However, it seemed to affect low academic achievers’ learning outcomes. Although it has partly been caused by the Ss anxiety about language, it might also have a relationship to their academic performance in general. On the other hand, the survey results showed that students were generally satisfied, and language was not a major parameter that affected the survey results. Research limitations do exist, but the results suggest the possibilities of educating subject courses to technical college students in English.

**Future Work**

The following areas need further research:
- Grade analysis and significance, if the vehicle language of Physics and Chemistry was Japanese first and then English.
- Measure whether there is improvement in students’ English language ability. (Proficiency Tests)
- Follow up the performance of the same group of students in the following years.
- Study the differences of learning outcomes between introductory courses and advanced courses.

**Acknowledgments**

We would like to thank professor Takeo Takahashi, the academic vice president of KTC, for his support, and for providing necessary data used for the analysis.
References

(文部科学省、「高等学校における先進教育」 (2017年11月14日)


“Kurashiki Declaration” (May 2016) by G7 Kurashiki Education Ministers: http://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2016/06/17/1370953_3_2.pdf


高等専門学校の充実に関する調査研究協力者会議、高等専門学校の充実について(2015)


Contact email: nagwa@neptune.kanazawa-it.ac.jp
Appendix I: School Survey Results of Computer Department

<table>
<thead>
<tr>
<th>Code</th>
<th>Survey Question</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Neutral (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>How satisfied are you with the current curriculum?</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>Do you think the course content is adequate?</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>How do you rate the teaching quality?</td>
<td>25</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>D</td>
<td>Are you engaged in extracurricular activities?</td>
<td>30</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>E</td>
<td>Would you recommend this course to a friend?</td>
<td>40</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: The table above represents a simplified version of the survey results. The actual survey included more detailed questions and responses.
Appendix II: School Survey Results of Mechanical Department

<table>
<thead>
<tr>
<th></th>
<th>回答者数</th>
<th>設問</th>
<th>設問</th>
<th>設問</th>
<th>回答者数</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>あなたは、この授業を難易度を持って受け続けられると思いますか？</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>この授業に対する期待を含めて、どの程度予習・復習しましたか？</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>あなたは、この授業に対して積極的に取り組みましたか？</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>あなたはこの授業に満足していますか？</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(続き)
<table>
<thead>
<tr>
<th>書 類</th>
<th>設問</th>
<th>そう思わない</th>
<th>あまよい</th>
<th>どちらかと割れない</th>
<th>そう思う</th>
<th>その他</th>
<th>回答率</th>
<th>各等級</th>
<th>標準差差-加重平均</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>あなたは、この授業を興味を持って受け続けられると思いますか？</td>
<td>30%</td>
<td>40%</td>
<td>30%</td>
<td>10%</td>
<td>10%</td>
<td>91%</td>
<td>20%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>50%</td>
<td>90%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>この授業に対し理解を含めて、どの程度予習・復習しましたか？</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>あなたは、この授業に対して積極的に取り組んでいますか？</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>D</td>
<td>あなたはこの授業に満足していますか？</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
<td>30%</td>
<td>20%</td>
<td>10%</td>
<td>100%</td>
<td>60%</td>
<td>40%</td>
</tr>
</tbody>
</table>

※回答率は程度が少ないほど役目が少ないことを示しています。