Effects of English Medium Instruction on Students’ Learning Outcomes in Science: A Case Study at a College of Technology

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英語媒体授業が学生の理科科目の学びにもたらす影響：高等専門学校の例から見えること

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概要

EMI（English Medium Instruction）即ち英語による授業は、近年高等教育を中心に、急激かつ世界的に広がっている現象である。日本でも高等教育改革や留学生増加対策、大学の国際化の文脈で、英語による授業を増やす方策が採られ、大学における EMI については少しずつ研究も進んでいる。本論では、まだ研究が進んでいない高等専門学校における EMI を取り上げ、1 年生の EMI 理科科目、日本語媒体（JMI）の理科科目、そして英語科目の成績を統計的に分析し、EMI が学生の学びにもたらす影響について調べた。その結果、EMI 理科科目と英語科目の成績の関連の強さは、第 1 クオータでは EMI 理科科目と JMI 理科科目の成績の関連と同程度の大きさであったのに対し、第 2 クオータでは EMI 理科科目と JMI 理科科目の成績の関連よりも有意に小さくなっていたことがわかった。また、EMI 理科科目と英語科目の成績の関連の強さは、学生の英語科目の成績の良さ・悪さによって有意に変化していなかったこともわかった。このことから、EMI の影響は、学生が英語による授業に慣れるに従って、数ヶ月の間に減少することが示唆される。EMI が第 2 クオータ以降学生の学びに全く影響しないわけではないが、これは、高等専門学校における EMI の導入にとって明るい可能性を示す研究結果と言える。

1. Introduction

English medium instruction (EMI) is one of the trends in current higher education worldwide, and it has also become more prevalent in East Asian universities including China and Japan (Kirkpatrick, 2011; Galloway & Rose, 2015; Fenton-Smith, Humphreys, & Walkinshaw, 2017; Rose & McKinley, 2018). In Japan, EMI is currently rapidly being implemented at universities selected for government-led large-scale internationalization programs such as Global 30 Projects and Top Global Universities Projects (TGUP). According to Rose and McKinley, Japanese universities moved from the more traditional essentialist and economic-oriented model of developing EMI courses to more European model of internationalization at least in their TGUP documents. Thus, rather than creating English

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language courses to lure and boost the number of foreign students, and offering native-speaker instructed English language education to train Japanese students, English is seen as the lingua franca of internationalized institution, and EMI courses are taken by both Japanese and foreign students, taught by both Japanese and foreign instructors regardless of their mother tongues (Rose & McKinley, 2018).

Internationalization is not only the topic of big TGUP universities. Even in a technical college such as the one in our current study, EMI has been implemented in order to internationalize the institution. However, although there is a rapid implementation of EMI courses at colleges and universities, and some research started to emerge (Chapple, 2014; Hino, 2017), there is not yet sufficient study on the effect of EMI instruction on students' learning in Japanese college of technology. Thus, in the current study, we hope to find out the relationship between Science courses taught in Japanese and English, and English language courses, in order to find out the effect of EMI in a STEM subject.

2. Current Study

2-1. Institution

This research was conducted at Kanazawa Technical College (KTC). KTC is a private college of technology of 5 years for 550 students aged 15–20 years old.[1] KTC has three departments, namely, Mechanical Department, Electrical Department, and Computer Department.

2-2. Education

EMI forms a part of KTC curriculum. EMI science classes have been implemented for Physics and Chemistry courses at KTC from 2016–17. Physics and Chemistry I, one of the subjects we have researched in this study, is a required 2 credit-hour course for year-1 students (15–16 years old). Physics and Chemistry I is taught in a pair teaching style by a Japanese and a non-Japanese instructors over four quarter terms. The non-Japanese instructor teaches EMI Chemistry part of Physics and Chemistry I classes as the main teacher in the first two quarters, then the Japanese instructor teaches

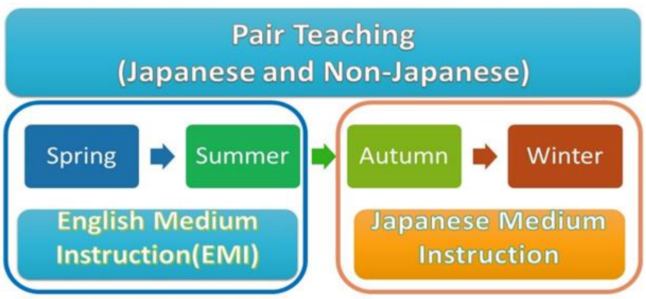

Figure 1. Year 2016–17 Physics and Chemistry I Flow

[1] The student number fluctuates year by year. In the year the data of this study was collected, it was 550.

Physics part of Physics and Chemistry I classes in Japanese for the following two quarter terms (See Figure 1). The main teacher in each quarter is in charge of lecturing and assessment, while the other teacher supports students whenever needed. Grading is equally divided into 25% each quarter term.

The assessment points in each term is divided into four criteria: 10 points for attendance and attitude; 30 points for classwork and assignments; 10 points for quiz; and 50 points for the final exams. The fail grade is below 60 points out of 100 points.

In 2016–17 academic year, the year our data has been taken, students in all three departments received Physics and Chemistry I instruction from the same two instructors. The textbook used for the first two quarter terms is a chemistry textbook in Japanese language that included science terminology and keywords in English. Although the main focus of the textbook was chemistry, it also covered other science topics such as physics, which were dealt in the autumn and winter terms of Physics and Chemistry I course. Except for the textbook, all the instruction in the spring and summer terms including lectures, PowerPoints, assignments, quizzes and tests, was conducted in English. Instructors assessed all students using the same grading criteria.

Another focus of the study was English language courses, English Reading and English Grammar, which students attended. Each course was taught by the same English language instructor, a Japanese national, in all three classes. The instructor used mainly English in class, but the lesson was not conducted in EMI style in the same extent as the Chemistry part of Physics and Chemistry I. The instructor used the same grading criteria for all departments.

2-3. Students' Identity and Achievement Level

The students of this study were all Japanese nationals who graduated from Japanese junior high schools. Thus, students' English language background was similar. Instructors have observed that the students were interested in hands on activities rather than theoretical study. Students' outlook of life was more vocational. In the past, about 70% of KTC graduates took up jobs in companies as technicians or engineers, and about 30% of the graduates continued on their study entering the third year of universities. The cohort in this study is expected to be not very different from their seniors in the selection of their future.

3. Research Questions for the Current Study

In order to find out the effect of EMI education, we have asked the following research questions for the current study:

When students are instructed science subjects in Japanese and English,

(1) do grading differences of students depend on the medium of instruction?

(2) do grading differences of students depend on students' ability in English language?

(3) do grading differences of students depend on students' ability in science?

4. Data and method

In order to answer the questions above, the relationship between students' performances in English classes, science classes, and English-mediated science classes was investigated using multiple regression analysis.

4-1. Data

There were 112 year-1 students in the academic year 2016–17. For four students, grade scores for the winter term were not available (three students failed and one student dropped), so grade data of 108 students during the 2016–17 period were used for this study.

In the grade data, students' grades for each class were on a 100-point scale. Some basic statistics of the grade data which were used in this study are given in Tables 1 and 2.

Table 1. Summary of basic statistics for the grades for the English classes

	English Grammar		English Reading	
Statistic	Spring	Summer	Spring	Summer
M	80.7	82.9	82.0	79.8
SD	12.5	12.5	12.3	12.8

Table 2. Summary of basic statistics for the grades for the science classes

	English-mediated Physics & Chemistry I		Japanese-mediated Physics & Chemistry I	
Statistic	Spring	Summer	Autumn	Winter
M	77.2	67.1	78.5	76.5
SD	13.1	16.3	12.4	11.3

Using the grade data, standardized scales for students' performance in English classes, science classes, and English-mediated science classes were constructed as follows:

1. Scale for an individual student's performance in English classes: ENG

For each student, ENG is the standardized score (*z* score) of the mean of his/her grades for English Grammar and Reading classes during the spring and summer terms.

2. Scale for an individual student's performance in science classes: SCI

For each student, SCI is the standardized score of the mean of his/her grades for Physics & Chemistry I classes during the autumn and winter terms, which were taught in Japanese.

3. Scales for an individual student's performance in English-mediated classes: ESCI1 and ESCI2

For each student, ESCI1 and ESCI2 are the standardized scores of his/her grade for Physics &

Chemistry I class, which was taught in English, during the spring and summer terms, respectively.

4-2. Method

The relationship between ENG, SCI, ESCI1, and ESCI2 was analyzed using ordinary least squares multiple regression with R (R Core Team, 2017).

After checking correlation between the scales, regression equations (1) and (2) were applied to the data.

$$\mathrm{ESCI1} = b_{01} + b_{11} \times \mathrm{SCI} + b_{21} \times \mathrm{ENG} \quad (1)$$

$$\mathrm{ESCI2} = b_{02} + b_{12} \times \mathrm{SCI} + b_{22} \times \mathrm{ENG} \quad (2)$$

To test whether the coefficients for ENG, b_{21} and b_{22}, are smaller than those for SCI, b_{11} and b_{12}, regression equations (3) and (4) were used, where the coefficients b_{21} and b_{22} in (1) and (2) are decomposed into $b_{11} + c_1$ and $b_{12} + c_2$, respectively.

$$\mathrm{ESCI1} = b_{01} + b_{11} \times \mathrm{SCI} + (b_{11} + c_1) \times \mathrm{ENG} \quad (3)$$

$$\mathrm{ESCI2} = b_{02} + b_{12} \times \mathrm{SCI} + (b_{12} + c_2) \times \mathrm{ENG} \quad (4)$$

If c_1 and c_2 are statistically significantly smaller than 0, b_{21} and b_{22} are statistically significantly smaller than b_{11} and b_{12}, respectively.

Finally, to check whether there is an interaction of SCI and ENG, regression equations (5) and (6) were applied.

$$\mathrm{ESCI1} = b_{01} + b_{11} \times \mathrm{SCI} + b_{21} \times \mathrm{ENG} + b_{31}\, \mathrm{SCI} \times \mathrm{ENG} \quad (5)$$

$$\mathrm{ESCI2} = b_{02} + b_{12} \times \mathrm{SCI} + b_{22} \times \mathrm{ENG} + b_{32}\, \mathrm{SCI} \times \mathrm{ENG} \quad (6)$$

5. Results

The correlation coefficients between the scales SCI, ENG, ESCI1, and ESCI2 are given in Table 3.

Table 3. Correlation matrix

	SCI	ENG	ESCI1	ESCI2
SCI	—			
ENG	.657**	—		
ESCI1	.737**	.733**	—	
ESCI2	.782**	.660**	.760**	—

Note: ** $p < .001$

The results of multiple regression analysis using equations (1) and (2) are given in Tables 4 and 5. In these tables, the intercepts of the models, which are all zero because all the scales used are standardized, are not shown. Also, note that partial regression coefficients in these tables are the same as standardized partial regression coefficients because of the same reason.

Table 4. Result of multiple regression analysis (1) for ESCI1

Effect	Coefficient	Standard error	*p*-value
SCI	0.451	0.076	<.001
ENG	0.437	0.076	<.001

Note: Adjusted R^2 = .65.

Table 5. Result of multiple regression analysis (2) for ESCI2

Effect	Coefficient	Standard error	*p*-value
SCI	0.614	0.077	<.001
ENG	0.257	0.077	<.001

Note: Adjusted R^2 = .64.

For ESCI1 (Table 4), the values of the coefficients for SCI and ENG (0.451 and 0.437, respectively) were similar. For ESCI2 (Table 5), however, the value of the coefficient for SCI (0.614) was larger than that for ENG (0.257).

To test whether the differences between these coefficients were statistical significant, multiple regression equations (3) and (4) were applied to the data. The result is that for ESCI1, the difference between the coefficients for SCI and ENG was not statistically significant at the confidence level 95% ($t(105) = -0.099$, p = .92). On the other hand, for ESCI2, the coefficient for ENG was statistically significantly smaller than that for SCI ($t(105) = -2.562$, p = .006, one-tailed).

Finally, to test whether there was an interaction effect between SCI and ENG, multiple regression equations (5) and (6) were applied to the data. As shown in Tables 6 and 7, the coefficients

Table 6. Result of multiple regression analysis (5) for ESCI1

Effect	Coefficient	Standard error	*p*-value
SCI	0.437	0.078	<.001
ENG	0.449	0.078	<.001
SCI × ENG	0.049	0.063	.437
Intercept	−0.032	0.071	.651

Note: Adjusted R^2 = .64.

Table 7. Result of multiple regression analysis (6) for ESCI2

Effect	Coefficient	Standard error	*p*-value
SCI	0.616	0.079	<.001
ENG	0.254	0.079	.002
SCI × ENG	−0.009	0.064	.887
Intercept	0.006	0.071	.934

Note: Adjusted R^2 = .64.

for the interaction term SCI × ENG were statistically non-significant for both ESCI1 and ESCI2.[2]

6. Discussion

In this section, we will consider results of the above statistical analysis in the light of some instructor observations concerning course contents and student attitudes.

Results of the statistical analysis show the following points:

(i) students' scientific performance (SCI) and English performance (ENG) were correlated with the students' performance in English-mediated Physics & Chemistry I (ESCI) in the spring term to about the same extent.

(ii) SCI was more strongly correlated with ESCI in the summer term than ENG was.

(iii) There was no significant interaction effect between SCI and ENG. That is, it was not found that, for example, lower performers of English showed much lower ESCI than other students.

We will look at (i) and (ii) first. (i) and (ii) show that there is a difference in the way ESCI was related to SCI and ENG in the first two terms. There are at least two factors which may affect the size of effects of SCI and ENG on ESCI:

(1) Contents of the class in the term.

ESCI would be less affected by ENG and more affected by SCI if the contents taught in the summer term required more mathematical skills. Similarly, ESCI would be more affected by ENG and less affected by SCI if the contents taught in the spring term mainly required understanding of concepts represented verbally.

(2) Familiarity with English-medium STEM education.

ESCI would be less affected by ENG (and more affected by SCI) if students got accustomed to English-mediated education.

[2] With the addition of the interaction term SCI × ENG to equations (1) and (2), the adjusted R^2 slightly decreased (by 0.001 and 0.003, respectively) and AIC increased from 199.4 to 200.7 and from 200.3 to 202.2, respectively. This suggests that the models with the interaction term, (5) and (6), are not so good as the models without it, (1) and (2).

However, concerning (1), we can presume that the effect of course content is small from the instructors' knowledge of the actual course contents. There was no strong bias in mathematical and conceptual contents in spring and summer terms. That is, summer content did not include more of the content that is independent of the language measuring skills (i.e., mathematical skills or similar) compared to the one found in spring term. Also, the same instructors conducted assessments and the structure and the balance of the assessment contents were similar in the two terms. So one can assume that there was little effect caused by the content or the format of the course.

On the other hand, concerning (2), we can presume that students' familiarity of EMI may have some effects from instructor observations of students. Instructors observed students showing anxiety about the use of English especially in the first quiz conducted in the spring term. Although students were participating normally in the English-mediated science classes, they orally expressed their worries about being assessed or taking tests in English (Rashed & Stevenson, 2017). That can explain why English and science were related to English-mediated classes to about the same extent during spring term. Students were not familiar with the particular assessment style, and those with stronger English ability may have felt more comfortable. A past study also shows that anxiety about the change in medium of instruction was one element that had an effect on their learning outcome especially in the beginning (Shiotani, 2014, September). With time and throughout the summer term students become more familiar with being taught science in English.

Next, we will look at (iii). The initial analysis of the grades misinterpreted the data, as it concluded that the change of vehicle language or language of instruction did not affect students learning outcomes in departments with high and medium academic achievers, but it seemed to have affected low academic achievers' learning outcomes (Rashed & Oyabu, 2017). However, in the current research, and with more careful analysis, the results suggest that there was no significant relationship between the grades of Physics and Chemistry I and English. That is, it was not found that lower performers of English have showed significantly lower performance on English-mediated Physics and Chemistry I compared to other students.

7. Conclusion and Future Directions

In this study, we looked at students' science grades in English and Japanese medium classes as well as their English language grades in order to find out if the medium of instruction significantly affect students' learning. Our findings show that initial strong relationship between English grades and EMI grades weakened within a few months as students got more used to EMI and that the weakening of the relationship held even for lower achievers of English language subjects. Although we can't claim that English Medium Instruction did not affect students at all, these are positive results in terms of EMI science education.

The study has limitations in that it is one year's data in one school, and no consideration of teaching styles of instructors was included. Also, as the first year of EMI education at KCT, students were not informed enough about EMI education before they entered the college, the situation which would be very different from the next academic year when the institution changes its name to International College of Technology (Kokusai Kousen) and students have been recruited internationally with a strong emphasis on EMI education.

Despite the fact that students in the current study did not choose the college for EMI education, students seem to be generally happy with the study in their first year. The results of the course survey, and students' self-assessment questionnaire that was done at the end of four terms, show that students were generally satisfied with the course regardless of their academic achievements (Rashed & Oyabu, 2017). The course survey and the self-assessment questionnaire did not include any question on the language of instruction. However, one student has written a comment at a free comment section that he (she) actually wished to be taught in English for the whole year. Although this is an individual opinion, so there is no indication that it reflects the feeling of the majority of students, it shows that there is at least some positive attitude amongst students towards the EMI course. Furthermore, there was no complaint or negative remarks about the EMI education. It can be said that the current study shows EMI may bring a positive learning experiences to technical and vocationally oriented students at a college of technology. We would like to continue our research as well as our efforts to make EMI more relevant to the learning of students.

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