

Thinking with Others about the Direction of Science: Enhancing Science Communication Skills through Audience Diversity

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ABSTRACT

Practicing science communication in English requires unknown and diverse audiences for the speakers to be aware of the effectiveness of their efforts and the challenges they will experience in face-to-face communication. The purpose of this study is to find out the effects of intercultural science communication between Japanese and international students through a science communication interview project. The results demonstrated that the majority of international students experienced profound reflections and transformations about their views on science communication by practice with Japanese students they were unfamiliar with. Importantly, most students recognized the unique challenge of practicing science communication with diverse audiences. In order to understand the wider social views on controversial science topics, promotion of intercultural science communication practice with unfamiliar, diverse audiences in university courses is strongly recommended.

KEYWORDS

intercultural communication, interdisciplinary learning, transformative learning, reflective essay

本稿は生物科学専攻の留学生が生命環境科学専攻および理工学専攻の日本人学生に対して英語で行った科学コミュニケーションの実践報告、その有効性をインタビュー結果及び留学生の書いた Reflective Essay からまとめたものである。社会的に合意が得られていない科学は未だ多数あり、これらを解決していくために理学系、工学系の学生は科学を学問として学び続けていくのと同時に、それについて不特定かつ多様な意見に常に耳を傾け、省察し、科学の今後のあり方について冷静に考察、決断していくことが重要と考える。実践結果では、多くの学生達が科学のあり方、およびコミュニケーション方法、そして日本人学生にたいする価値観にいたるまで深く内省し、考え方を多様に変容していくことが解った。多数の学生達がこのような実践的な形態で行う科学コミュニケーションの必要性を理解したことから、今後の大学における科学コミュニケーションの実践練習を異文化・異言語間、また異なる学問背景の学生達同士で練習していくことは科学のあり方、またその民主的決断を促すうえで非常に有効とし、提案していきたい。

1. Context

In science, facts and truths are discussed and communicated through highly technical terms and concepts that often trouble less-specialized audiences and prevent them from understanding the true meaning and purpose at hand. However, science and technology is an integral part of our culture that heavily influence our daily lives. Scientific knowledge and applications are powerful and exciting thus it is reasonable for the public to want to know about these new advances and questions they raise in our society (Bowater and Yoeman, 2013). This is where science communication plays a vital role, offering a chance for all the diverse aspects of public and society to learn from scientists about potential impacts of new advances.

Intercultural communication is defined mainly as face-to-face communication between people from diverse national cultures (Gudykunst and Mody, 2002). Intercultural communication processes, however, can become complicated where there are additional pressures, like language and cultural barriers (Byram, 1997). Moreover, scientific knowledge particularly is shared and understood by a highly limited number of people, and the highly specialized nature of this knowledge can make it even more inaccessible to the other members of the society they are immersed in (Reyes-Galindo and Ribeiro Duarte, 2017).

Currently, Japanese universities are promoting the use of English among undergraduate students as the number of international students dramatically increases (MEXT, 2017). If the number of international people increases in Japanese society, science and engineering students will need to be able to effectively practice oral science communication skills from an early stage (Brownell, et al., 2013).

Science often contains controversies and sometimes even mistakes. Pros as well as pitfalls exists in many science topics that need to be communicated and shared with society as a whole in order to find better solutions. The development of nuclear physics in Manhattan project led to discussions about the dual use of technologies for both good and bad purposes (Davies and Horst, 2016). A Pew Research Center survey revealed there still exists striking differences between the public's views and the view of the scientific community with regards to many topics, from whether genetically modified foods are safe to eat to whether the world's growing population will be a major problem (Pew Research Center, 2015). The general public has loudly condemned the poor communication practices around critical science topics, often blaming the scientists themselves (Gilbert and Stocklmayer, 2013). Under these circumstances, it is never too early for university students to practice interdisciplinary science communication skills to prepare them to rationally discuss both the benefits and limitations of science, improve their ability to learn from real voices, and consider different directions of science for our future. Japan is employing this approach starting in the early stage of university to make students aware that all scientists and their opinions belong to society (Japan Society for the Promotion of Science, 2015).

By experiencing diverse perspectives about science, learners will elaborate and transform their ideas in a more socially-adjusted, refined, and realistic direction that reflects the views of all members of society. This transformative

learning process enhances the self-reflective process that involves four processes of learning below (Mezirow, 1997 cited by Hoggan et al., 2009):

1. Elaborate an existing point of view
2. Establish new points of view
3. Transform our point of view
4. Become aware and critically reflective of our generalized bias in the way we view groups other than our own.

This process allows learners to become autonomous thinkers, which is vital for the development of moral decision making in times of rapid change (Mezirow, 1997 cited by Hoggan et al., 2009).

The study explores the effectiveness of science communication interview project that was undertaken between university students of international program and Japanese program. To see the reflective transformations students have gone through, the effectiveness of intercultural and interdisciplinary science communication was evaluated based on students' efforts, challenges, and their awareness of what they experienced in this project.

2. Methodology

Course Objective and Participants

This science communication interview project was conducted as a course assignment for international students during the fall semester in 2018 (Japanese students had a different project called the intercultural communication interview project that was done using the same opportunity in a separate context having different course objective). The course objective for international students was to clearly explain and present about both the pros (the achievements and contributions) and the cons (the limitations and potential risks) of science (one controversial topic and one interesting science topic, freely chosen by the students) in an understandable way. So that the Japanese students in the audience could clearly comprehend their stories. This interdisciplinary and intercultural science communication project was intended to enhance students' learning about diverse perspectives and to authentically promote students' practical science communication skills. Students were provided a free discussion space away from their classroom, away from their instructor, in order for them to have a chance to learn from students they did not know by face-to-face, and reconsider about how they believe about science through science communication practice.

The total number of course participants was 83 Japanese and 27 international students. The Japanese students (audience members and interviewees) were a mixture of students from the School of Life and Environmental Sciences and the School of Science and Engineering. The international students (presenters and interviewers) were from the Department of Biological Science. Interview answers and reflective essay comments were collected from 64 Japanese and 12 international students to examine the effectiveness of this project. I received permission from the students to use both their interview answers and reflective

essay comments in advance. Additionally, this research did not have any relationship to their course evaluations.

Pre-Project Survey, Science Communication Interview Project, and Reflective Essay

A pre-project survey was conducted with Japanese students to understand which science topics their audience perceived as controversial (Table 1).

Pre-project survey question:

‘Which three science topics/facts do you think are still unknown about the real effects thus difficult for lay people to accept? Please tell the reasons why they are controversial’.

Table 1. Pre-Project Survey Results

No.	Controversial Science Topics	Number Answered
1	AI	20
2	GM food	14
2	Autopilot car	14
3	Gene recombination	13
3	Cloning	13
4	Nuclear energy	12
5	IPS cells	9
6	Hydrogen water	6
7	Global warming	5
8	Aliens	4
8	STAP cell	4
8	Supplement	4
8	Radiation to cure cancer	4
9	Space travel	3
9	Food from Fukushima	3
10	The theory of relativity	2
10	Euglena is healthy to eat	2
10	Black hole	2
10	Perceptual youth and longevity	2
10	The theory of evolution	2
10	AR/VR technology	2
	Other individual topics	20

(Top three choices collected in total=160)

Science Communication Interview Project

Presentation and Interview Process

1. Based on the collected results of Table 1, each international student freely chose one controversial science topic and prepared his/her explanation in a clear storyline containing both the pros (the achievements and contributions) and the cons (the limitations and potential risks). *
2. Like above, each international student chose another science topic based on his/her own interest to prepare the story containing both the pros and the cons.
3. Japanese and international students mutually made contact with each other to arrange the time to meet in the university central library discussion room. **
4. When meeting, the international student presents about a controversial science topic, science topic he/she is interested in, and then receives a comprehension check from Japanese students to rate the understanding. The comprehension check helps the international student to evaluate his/her own science communication skills.
5. After two presentations, the international student asked three interview questions in order to perceive and reflect about the audience's understanding of scientific achievements, contributions, limitations, and potential risks. These three questions were:
 - ① Which scientific facts do you trust (including commercialized products that are based on scientific evidences)? Why do you trust them?
 - ② Which science do you need more explanations to trust? Why are they difficult for you to understand and trust?
 - ③ Tell us any commercialized products that are already scientifically proven to be safe and effective but still hesitant to buy or support. Tell the reasons.

*International students could prepare and create extra tools, drawings, and materials such as Microsoft PowerPoint slides to support presentations. In addition to English, they could also speak Japanese when necessary.

**Each international student had an average of three to four interviews (two Japanese audience per interview) with different members each time.

Reflective Essay

After completing all interview tasks above, each international student prepared a reflective essay to wrap up the project. In the reflective essay, students were asked to consider ways they tried to fill the gap between unknown and diverse audiences in terms of the kind of effort they made in difficult situations and major challenges they faced. Furthermore, students were instructed to critically analyze how they transformed their views and values on science, science communication practice, and the students who made up their audience.

Data Collection

In order to reconfirm the majority of audience students' perception of critical science topics, additional data was collected and visualized from two interview

questions below. The data corresponded to many comments made in the reflective essays. Later, reflective essay comments on efforts, challenges, awareness and reflections during the whole interview process were further classified to evaluate the effectiveness of this project (Figures 3, 4, 5, 6)

3. Results and Discussion

1. Interview Answers

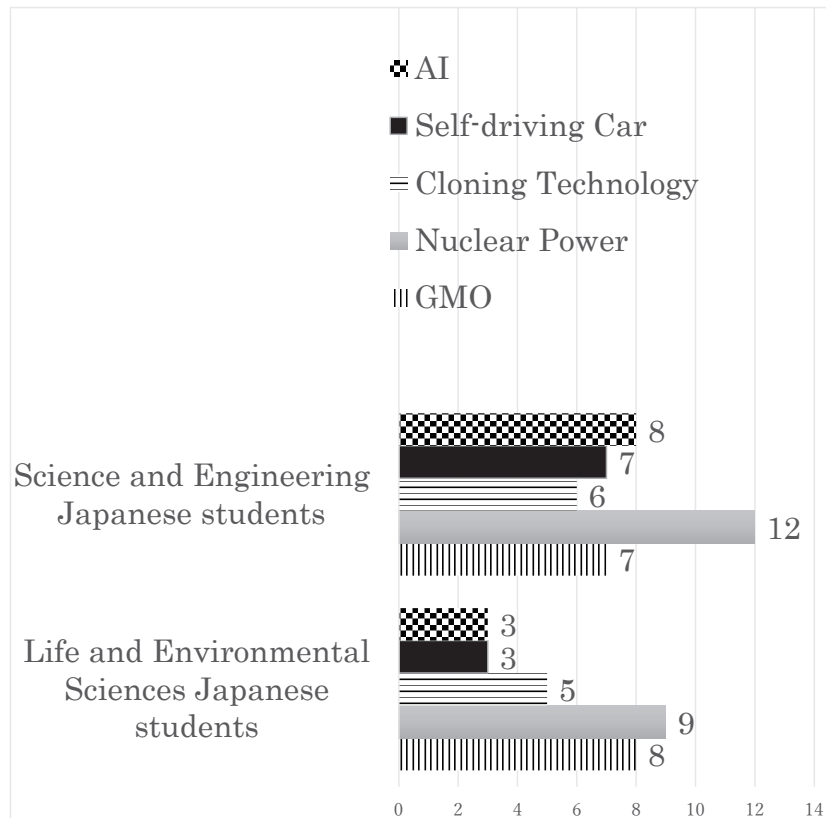


Figure 1. ② Top Five Science Topics that Need More Explanations to Trust (Top 5 totals=68 in 151 answers)

Figure 1 data was collected by international students from the question ②. Surprisingly, the top five science topics that students needed more explanations to trust were very similar between the students of both majors.

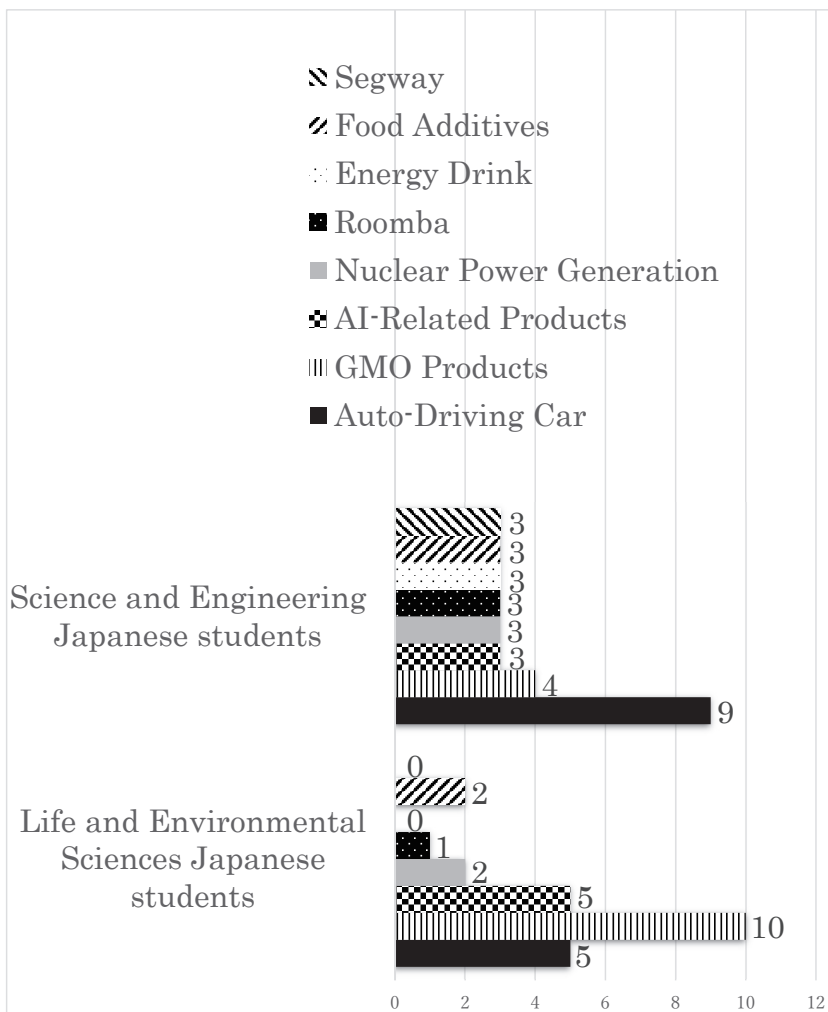


Figure 2. ③ Commercialized Products Hesitant to Buy or Support (Top 8 totals=56 in 143 answers)

Figure 2 data was collected by international students from the question ③ . As can be seen from the graph, the answers were extremely diverse. The results showed that the majority of students were concerned about engineering subjects such as driverless cars and GMOs.

2. Reflective Essay

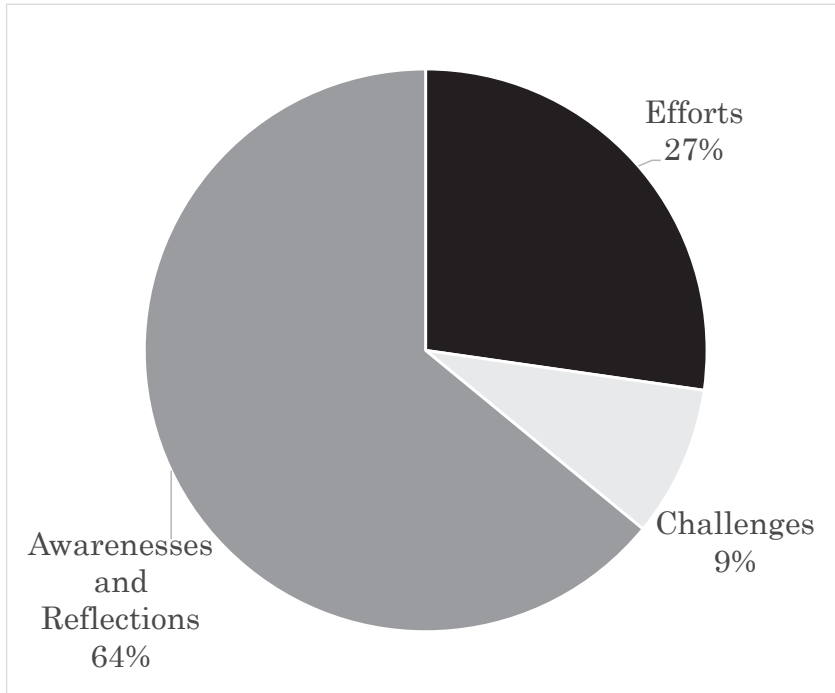


Figure 3. Efforts, Challenges, Awareness, and Reflections in Science Communication Interview Project (Total comments collected=242)

Figure 3 is about the number of overall comments based on three different categories: 1. Efforts, 2. Challenges, 3. Awareness and Reflections international students commented in their reflective essays. The result turned out to be surprisingly positive, as their efforts, awareness, and reflections overwhelmed the challenges they faced. This result demonstrates that the combined percentage of ninety-one percent (the addition of efforts plus awareness and reflections) of students, means that the vast majority of students reflected, learned, and positively transformed themselves in this science communication interview project.

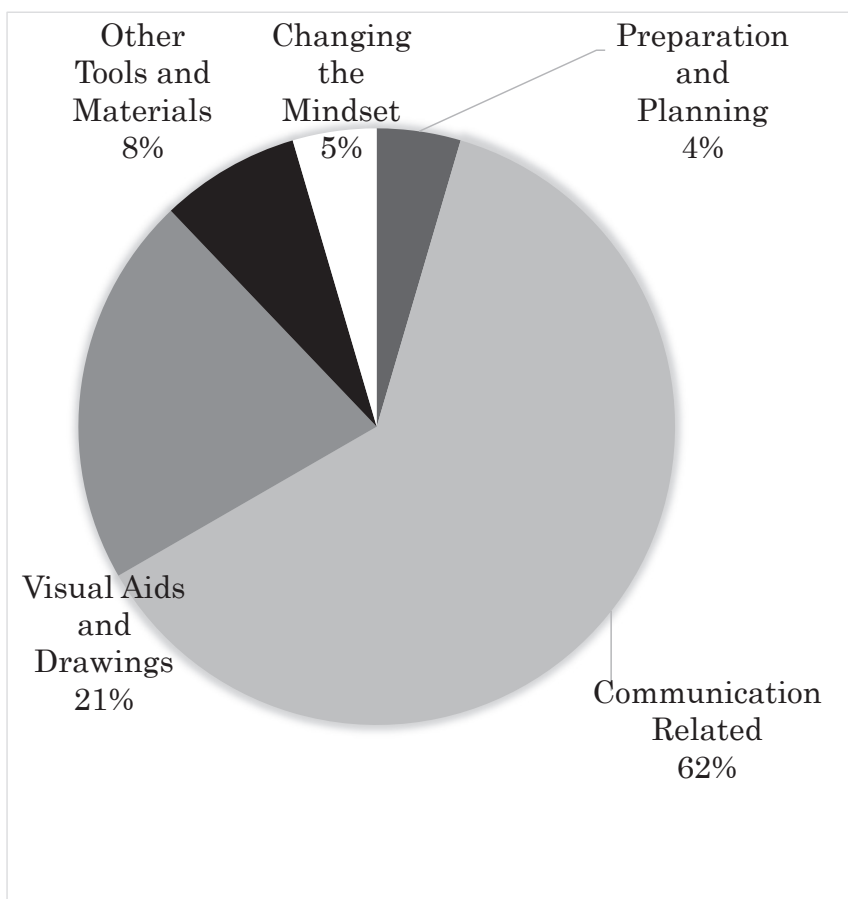


Figure 4. Efforts Made during Interviews (66 total comments collected)

Above graph shows the efforts international students made during the interviews. Communication-related efforts made up the majority, consisting of sixty-two percent. Twenty-one percent were about the efforts students made, creating visual aids and, drawings, and an additional extra eight percent was related to tools and materials they created and used. Hence, in total, twenty-nine percent of the efforts related to tools they used.

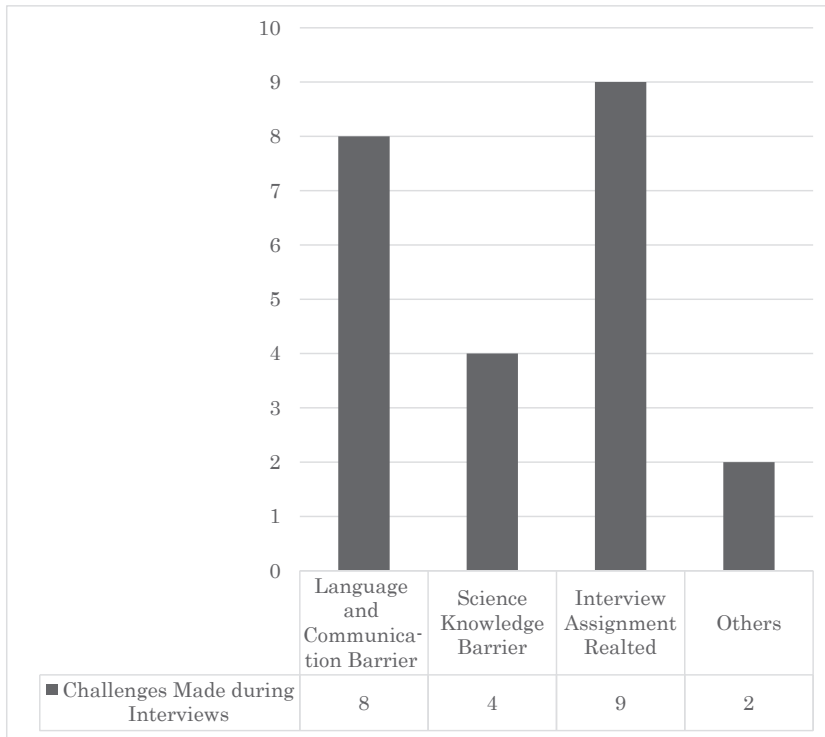


Figure 5. Challenge during Interviews (23 total comments collected)

Twenty-three comments were collected about the challenges international students faced during the interviews. Eight comments were given about the difficulties in language communication barriers. Additionally, nine comments were given about the difficulties of this assignment. However, the majority of students clearly made an effort in creating and using communication tools to be effective, thus this challenge cannot simply be seen as an unnecessary process for their transformations and improvements. Nevertheless, any negative opinions should not be disregarded. Thus, alternative strategies need to be considered in order to reduce the stress of participants.

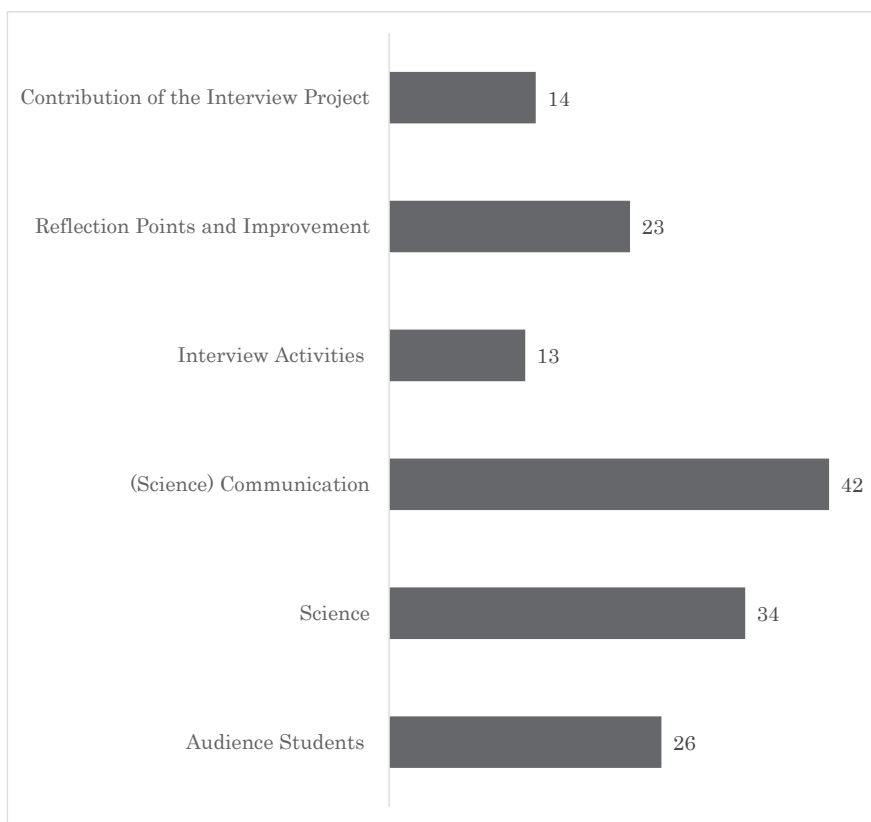


Figure 6. Awareness and Reflection from Interviews (152 total comments collected)

Awareness and reflection on science communication interviews are shown on Figure 6. As can be seen from the graph, students seemed to have learned and changed their views tremendously from this science communication interview project. More than one-hundred fifteen comments were given about science communication activities (No.1, No.2, No.3, No.4), and fifty percent, a total of seventy-six comments, were given about science and science communication. Twenty-four percent of comments (No.4 and No.5) were about improving their practice and further mentioned the importance of meeting people to practice the subject (See Appendix for the actual comments given). Above all, the vast majority of comments about this project turned out to be positive.

Pedagogical Recommendations

The majority of university courses and assignments are based on decisions made by the instructors. Communication-related courses are not an exception thus students do not have much room to negotiate with instructors about the practicality of the content. Traditionally, the audience has not been employed as a vital factor for improving students' skills in science communication courses.

Many courses use the members of the class as the audience for students to practice their skills on (Kuehne et al. 2015 cited by Marino and Dragan, 2019). Using controversial science topics to promote discussions about solutions is a democratic process that requires reflection about social and universal demography, and thus employing unfamiliar audiences was preferable in this situation. This implies that having diverse audience members who are unrelated to the course is extremely important for learners. Future science communication courses will benefit from having more intercultural and more interdisciplinary mixture of audience members, who are not associated with the presenters' own circumstances. Going through the numerous unknowns can help the students build practical skills to master authentic science communication.

Conclusion

Science communication practice with students drawn outside of your own class can provoke objective yet constructive feedback and profound reflection. The purpose of this study is to examine how much reflective transformation biological science major international students experienced in intercultural interdisciplinary science communication with Japanese students. The results showed that the majority of students experienced positive transformations from this activity. Many felt stimulated and furthered their practice of science communication with unknown diverse audiences. As results suggest, communication courses require audiences from outside the class to enhance their practicality. Future science communication should promote understandings beyond the border of languages, cultures, and specialties that foster real solutions to unsolved science topics around the world.

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Appendix. Awareness and Reflections from Interviews

4. About Interview Activities: 13

- 1 The interview was a chance to become aware of each other's perspectives and thoughts on a science that concerns both of our futures.
- 2 Talking about contrasting ideas over a certain point permitted us to learn from each other while thinking critically on how better things can be done (analyzing things in a wider view).
- 3 It is also important to consider that everyone has a different level of grasping new knowledge.
- 4 After the first interview, I was triggered to search more about Japanese society and politics.
- 5 Enjoyed the exchange of our views on cultures and lifestyles of Japan.
- 6 At the end of the tunnel, the experiences enabled me to acquire multiple skills as well as bettering the ones I had including patience, active listening, and critical thinking.
- 7 Making adjustment in pictures and slides enhanced my creativity.

- 8 Each student had unique ideas.
- 9 I was truly amazed by her simple yet thoughtful answers.
- 10 Made me think that similar problems can exist everywhere but in a different mode of varying magnitudes.
- 11 I learnt more about Japanese cultures which raised my curiosity on some points.
- 12 By the end of this task, my brain was so much altered, realizing how countries share similar problems though in different approaches.
- 13 How crucial unity is for anything we want to make happen.

5. Reflection Points and Further Improvement: 23

- 1 Instructor to be in interviews to give guidance and support.
- 2 I would like to have my computer or phone more to show interesting short videos along my speech.
- 3 I would like to have small games to ensure how much they learned in future to make it more fun.
- 4 I would provide more eye-catching pictures and animations, to encourage attention of the audience.
- 5 Include interactive games or tasks, like drawing picture of how he/she imagines the hemoglobin or making Origami of the cell. Because these tasks involve their creativity and helps to digest new knowledge smoothly.
- 6 It is crucial to find connections via different methods, like associations or experiments, in purpose of sharing knowledge.
- 7 The interview could be more engaging by putting more interesting facts into my stories and arranging in a way that could let them wonder about the topic.
- 8 When I found they had difficulties in catching up with me, I printed out my words; when I found they were too shy to ask me questions, I approached to them actively and encouraged them to ask questions in Japanese; when I realized that they didn't have basic knowledge for biology in English, I explained the word in Japanese for their better understanding. Meanwhile, I developed better storytelling abilities in practicing through the project.
- 9 However, experience is not enough to successfully finish this interview project. I still need to adjust my style of teaching according to what kind of person I am facing, make my range of teaching wider.
- 10 We must be able to pick up the strongest message depicted from our research. This will help us in critical analysis and intellectual debates of the key points.
- 11 Know what the audience expects and needs from the presentation/talk. Analyze the type of audience, considering all the minorities, and explore what they need to know to improve their understandings.
- 12 The key is to decide on the goal of our communication and explore successful ways to trigger human emotion and inspire action through the ideas.
- 13 Excellent science communication triggers imagination and critical thinking enabling captivating discussion and debate that promotes science in the society.

- 14 Effective scientific communication can earn mutual respect between science and society, and these communications will encourage and motivate others to change the future.
- 15 A Japanese student made me realize that, every scientific advancement has a downside, and we often fail to perceive it.
- 16 The ability to think critically, inspire changes, and changes inspire awareness. She exhibited this skill, despite her poor English ability.
- 17 Seeing a smile in his face, after getting the answer, helped me boost my confidence as a biologist and my skill in exchanging intercultural communication.
- 18 His answers, were less persuasive and made me realize that, not every Japanese is good at critical thinking and interpreting their thoughts.
- 19 From her interview, I have learned that she is aware of the scientific terminologies, facts, and showed her ability to think critically.
- 20 I have realized that the interviewee is aware of a wide range of scientific facts ranging from refrigerator gas to microchips used inside human in Sweden.
- 21 However, one thing that was a bit strange was, he was well-informed and knowledgeable about all the merits of GMO, but he said he still refuses to eat it. Does it mean he doesn't trust the scientific facts? He replied-he just doesn't want to eat them because he saw TV program regarding bad sides of GMO.
- 22 Now I feel very sorry for this student, because I didn't encourage him in the correct way, which can be count as a kind of language violence, hurting his self-respect.
- 23 Noise of Sohosai... because of this, I was more careful at selecting the time and place of the interview, or it will waste some time in dealing the unrelated things.

6. Contribution of the Interview Project: 14

- 1 People have amazing stories or ideas about various issues like environment, but it requires us to meet those people to know how great their ideas are.
- 2 I found knowledge that was gained via practice is more interesting and influential to people.
- 3 The interviews we conducted helped me to realize that I will be doing the same thing those scientists once taught me, and I also feel with the responsibility of doing such.
- 4 Overall, I can say that though from the outside this may have seemed to be a not very useful project. However, after doing it not only did it help me to focus on the small details that in the end make a big impact when it comes to interaction, teaching and understanding biology to native speakers and non-native speakers alike but it also gave me the chance to interact with Japanese students which I wouldn't have otherwise interacted with in the first place.
- 5 My partner said that he really appreciated this chance of communication with foreigners which made me happy because I was the first foreigner

that he talked to.

- 6 Little communication between foreigners and Japanese, and between biology students and non-experts, so the project provided me precious chances of talking about what I learned to the audience who weren't very good at listening to and understanding what I said.
- 7 In teaching others, we teach ourselves. Intercultural science communication is a great way to acquire useful experiences and use it for our self-development.
- 8 I learned about Japanese students as individuals, I learned about their nature and their way of communication. I exchanged our knowledge and cultures, I taught them my cultures and interests in science and they did the same. This whole thing is really important to circulate science knowledge and improve human relationship at the same time. The entire activities that we did are really interesting, and it all leads to one thing "understanding".
- 9 My whole reflection about this is about understanding people, it is always easy to know people but it's really hard to understand them. If we can't place myself in their shoes and understand them, I won't be able to fulfill the gap that we had.
- 10 I learned that no matter how different we are in terms of cultures and personalities, we aim the same goal, which is to learn and gain new experiences.
- 11 By doing science communication, I became both a teacher and a learner at once.
- 12 How to give a meaningful English communication or presentation is a project deserves us to further explore.
- 13 As a biologist, and future scientist, it is a priority, to know how to share ideas and knowledge with public and make it more accessible and trustworthy. The only way to develop this skill is to engage in intercultural science communication with a more diverse ethnic people around the globe.
- 14 All students had unique interesting notions which helped me to develop a stronger desire of meeting more Japanese people so that I learn more about their perceptions on various social political and environmental issues.