論文

Joining the Global Research Community: Japanese High School Students and Scientific Networks of Collaboration

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Abstract: Scientific knowledge is discovered by teams of researchers, often working across the globe. Researchers need to master the social dynamics of forming collaborative networks. The current study examines the use of social network analysis to train Japanese and European high school students to form collaborative networks with intentionality. While collaborating on science projects, the students were taught how to utilise social media tools from a network perspective to form collaborative networks. After the students met in Europe, a corpus analysis of the Japanese participants' learning diaries and recollections were compared to a control sample of another group who participated in a similar program but without the network workshop. Analysis confirmed that the group who received the training demonstrated a higher level of understanding of the project, greater feelings of competency, and a deeper insight into how to interact in a multicultural environment than did the control sample.

Keywords: Japan, International exchange programs, High school, Science education, Collaborative networks

1. Introduction

While Japanese engineering is world-renowned, the world ranking of its universities are surprisingly low (Times Higher Education; 2020). 'International outlook', which accounts for international faculty and staff along with publications with international co-authors, is a major weakness for Japanese universities. The University of Tokyo's international outlook rating was 38.2, and Kyoto University follows close behind at 33.7. While other four universities International Outlook rates slightly over 40 most of the top 50 universities have scores over 90, with only University of Tokyo and University of Texas at Austin dropping below 40. Japan faces a variety

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of barriers to global integration, including problems in English language education; the national average for TOEIC was 28 out of 32 sampled countries - among the lowest (ETS, 2021). However, beyond the basics of reading, writing, listening, and speaking, there are also sociocultural barriers to overcome. For Japan to increase, or even maintain, its international standing in science and technology, its scientists and engineers must build relationships with international partners and have the intercultural and social competence to maintain and expand those networks of collaboration.

1-1. English Education, Overcoming Sociocultural Barriers, and Social Skills Training

There are various pedagogical approaches to foreign language education; generally, they focus on the granular components of language – grammar and syntax, learning vocabulary, and practising the four communicative skills of reading, writing, listening, and speaking (Mitchell, Myles, & Marsden, 2019). Unfortunately, none of these methods directly address the sociocultural problems that Japanese researchers face in forming transnational research networks. While progressive English as a Foreign Language (EFL) textbooks might approach some of the shallower issues of cultural difference, they do not address sociocultural differences that create communicative difficulties for Japanese people in multicultural settings. Bradford (2016) cites research showing issues with background knowledge (Tange, 2010), cultural approaches to learning (Eaves, 2009), and intercultural competency (Kuwamura, 2009) for Japanese students. Another common issue is differing communication strategies between collectivist cultures versus individualistic cultures (Ting-Toomey, 2017). Consideration of fundamental social skills such as how to build professional or personal relationships quickly, the balance of listening to talking, and other core skills for successful communication in diverse settings are necessary.

In counselling fields such as counselling psychology, guidance counselling, and clinical social work, there is a wealth of conceptual models and evidence-based modalities for working with clients to master appropriate social and communicative skills to improve one's interpersonal relationships (Beelmann, Pfingsten, & Lösel, 1994; Maag, 2005; Mathur, et al, 1998; Schloss, et al, 1986). Understanding and having the skills to approach other researchers in a relevant field, discuss with them about potential future collaborations, and maintain a professional relationship are all important social skills that can be explicitly taught, thereby leap-frogging the lengthy natural process of observation and trial-and-error that someone unfamiliar and anxious

might need in order gain the social competence needed to succeed.

1-2. International Exchange Programs

International Exchange Programs are one way in which countries attempt to import knowledge, increase multiculturalism, and increase foreign language skills. In Japan, most students will participate in short-term study abroad, the goal of which is generally educational and cultural exchange (Perna, et al, 2014). Many of the programs are a month or even shorter. International exchange for adolescent students has been shown to benefit self-esteem, identity development, social development, and global awareness (Hutteman, et al, 2015; Greischal, et al, 2018; Furukawa, et al, 1998). Building social relationships, learning to navigate the host culture, developing a life outside of schoolwork, and having a sense of belonging appear, among other factors, appear to be important to international student success (Moores & Popadiuk, 2021). However, there is some debate about whether there is any benefit from short-term as opposed to longer-term programs (Mapes, 2020).

Short-term exchange programs generally fall short in terms of preparing Japanese students to take part in international collaborative research networks. Intercultural competence is best developed well-planned programs that have a well-designed pre-departure program to support intercultural communication and competence (Hanada, 2019). We suggest that by creating a program that adopts a network perspective, where high school students are explicitly trained on how to form international collaborative knowledge networks, students will be able to demonstrate the ability to use English to participate in scientific knowledge networks.

2. Methods

The hypothesis for this project is that Japanese high school students who complete a training module on networks of collaboration and communication skills for science as part of preparation for international exchange will collaborate more effectively with students from other countries than do students who do not receive the training module.

2-1. Participants

Participants were 29 Japanese high school students 16-19 years old in a STEM program sponsored by the Japanese government. As the students were pre-selected to participate in the STEM program, in the scope of this project, convenience sampling was used.

2-2. Design

This project utilised a mixed method, quasi-experimental design. Two groups, a control group and experimental group, completed a STEM program in Japan and travelled overseas for an international science experience. The control group completed the STEM program and, in

addition, had 3, 5-hour sessions with a native speaker English instructor, two days of 'Communication Study' with a Japanese instructor, and a homestay orientation to improve their production of English output; the experimental group completed a similar training while also receiving an extra training module. The extra training module included: 1) knowledge-building around the social construction of science, including the importance of transnational collaborative networks; 2) an introduction to social network analysis, including a side project of compiling social network data from the participants and a discussion of the metrics of their group's own networks; 3) Group discussions and problem solving around how to interact with other researchers in an international setting, including how to show interest, when it is appropriate to ask questions, and how to share opinions; and 4) Online introductions and research project planning with the European students they would meet face-to-face when they went overseas.

Students from the control group (n=19) participated in the STEM program one year, while the experimental group (n=10) participated the following year. The STEM components taught within Japan were similar. Students from both groups went to Europe for nine days, although the two groups went to different sites. During the international exchange component, both groups attended lectures, had question and answer sessions with researchers, met foreign students, and received site tours of research facilities.

2-3. Data Collection

Members of both groups completed surveys and wrote post-program reports about their experiences. Additional data for the control group consisted of teacher observations, and data for the experimental group was supplemented with transcriptions of onsite video recordings of the final question and answer session in Europe.

The written data from the experimental group was taken from the participants' Japanese hand-written, post-trip reports. The hand-written reports were transcribed and checked for accuracy by two native Japanese speakers. The written data from the control group was taken from the group's post-trip report published and distributed by their high school. Each participant's report was scanned, and the data was digitised with Optical Character Recognition (OCR) software.

2-4. Data Analysis

Text analysis of the written reports by the control and experimental groups was performed using an online corpus analysis system which gives a quantitative summary of the written feedback to identify keywords, collocated phrases, and usage contexts. Data was analysed in Japanese and results were translated into English.

Awareness of the importance of networks was operationalized to identify key terms and their frequency. A term was selected as a keyword if it related to science, international networks, or global research. The significance of any differences in the number of participants using a term was calculated using Fisher's Exact Test. This was followed by a second analysis to assess the words around each use of the keywords to determine the context in which the keywords were used. These contexts were then examined to see if the keyword was being used within the context of international scientific collaboration or research. Fisher's Exact Test was calculated again to determine if there were non-random associations of the keyword occurrences by participants in the control and experimental groups, one-tailed, with an alpha level of significance set at $p<.05$.

The video transcription from the Q&A session for the Experimental group (the control group asked no questions, so there was no data) was analysed separately by hand.

3. Results

The total corpus has 29 documents with 24,427 words. Eleven keywords were found in the corpus related to international scientific research networks, as seen in Table 1.

To determine if the proportion of participants using the keywords by participants in the control group and the experimental group were independent, and because of the small sample size, Fisher's Exact Test was used. The count of participants in the experimental group who used 'research' (*x^2=0.0004); give an opinion' (*x^2=0.0302); and 'science' (*x^2=0.0021) was significantly greater ($p<.05$) than the control group.

Table 1. Participants Use of Keywords in Control Group v. Experimental Group Texts

Keyword	Ctl (n=19)	Exp (n=10)	Fisher's Exact Test
'trip'	19	9	x^2=0.3448
'English'	17	10	x^2=0.532
'overseas'	13	7	x^2=1
'experience'	12	8	x^2=0.4311
'research'	6	10	*x^2=0.0004
'communication'	13	5	x^2=0.4119
'presentation'	4	6	x^2 =0.0514
'experiment'	7	6	x^2=0.2701
'give an opinion'	2	5	*x^2=0.0302
'questions'	4	4	x^2=0.3904
'science'	2	7	*x^2=0.0021

*p<.05.
Ctl = the number of students in the control group who used the keyword
Exp = the number of students in the experimental group who used the keyword

3-1. Contextual Analysis

The same 11 keywords were re-evaluated by looking at their contextual usage. The usage of eight terms changed to show a significantly greater usage by the experimental group.

After re-evaluation, only six control group participants refer to 'trip' in a context of making friends with people overseas or discussing a science festival that was part of the trip, while nine of the experimental group discussed their trip in the context of thinking how science is global, working with their foreign partners, or their achievement in developing better presentation skills. Significantly more of the experimental participants used 'trip' in the context of international scientific networks (x^2=0.0052). This tendency was seen also in the usage contexts of 'overseas';

'experience'; 'communication'; and 'questions'.

Regarding 'overseas', there was no significant difference between the number of participants in the control and experimental groups, but a significant greater number of experimental group participants used 'overseas' in the context of science, making friends, and connections (x^2=0.0088). Exp 10 remarks how the study tour helped him realize that science is the same everywhere, and that there isn't "Japanese" or "foreign" research, while the control group talked about overseas in the context of studying abroad during university.

Table 2. Occurrences of Keywords in Control Group v. Experimental Group Texts After Contextual Analysis

Keyword	Ctl (n=19)	Exp (n=10)	Fisher's Exact Test
'trip'	6	9	*x^2=0.0052
'English'	3	8	*x^2=0.0013
'overseas'	0	4	*x^2=0.0088
'experience'	1	7	*x^2=0.0005
'research'	1	9	*x^2=0.00001
'communication'	2	5	*x^2=0.0302
'presentation'	4	6	x^2=0.0514
'experiment'	7	6	x^2=0.2701
'give an opinion'	1	5	*x^2=0.0105
'questions'	1	4	*x^2=0.0357
'science'	2	7	*x^2=0.0021

p<.05.
'Control Group Frequency' = Ctl; 'Experimental Group Frequency' = Exp

A significantly greater number of experimental participants used 'experience' in the context of science (x^2=0.0005). The control group use 'experience' to talk about their interaction with their homestay families or general travel anecdotes.

Likewise, the count of 'communication' and 'questions' changes after considering the context. A significantly greater number (x^2=0.0302) of the experimental group used 'communication' to reflect how science is a global effort or to recount conversations with their foreign partners. In contrast, many of the control group used 'communication' to talk about their general English ability and interactions with their host families. With 'questions' too, a significantly greater number (x^2=0.0357) of the experimental group connected it to international science, collaboration, and global networks than the control group.

An additional awareness of science, research, and international networks emerged in the usage of 'research' and 'give an opinion' by experimental participants with no change in the proportion of participants using 'science'. 'Research' was used significantly more by the experimental group (p=0.0004). Interestingly, in the control group texts 'research' relates to someone else's research, while nine of the ten experimental participants mentioned 'research' in more immediate, personal contexts; furthermore, seven of those reflected on the benefits from international collaboration. For example, one student mentioned that to carry out high level research, it is obvious that international collaboration is necessary.

Finally, after considering the usage, distinct differences emerged between the control and the experimental group in their attitude towards 'English'. The control group was negative about their English. One student confessed that she cried during the trip due to the stress of being surrounded by English. In contrast,

the experimental group was positive. Of course, they relate difficulty with English, but in a sense of achievement rather than defeat: one wrote ‘I felt the difficulty of English communication but also the pleasure of understanding’.

4. Discussion

The hypothesis of this project was that Japanese students who study a training module on networks of collaboration and social skills for science will collaborate more effectively than do students who do not receive the training. The results of this analysis support the hypothesis, suggesting that Japanese high school students benefit from explicitly learning about the importance of collaborative science networks and from practising the social skills needed to form and maintain research relationships. Participants in the experimental group showed greater awareness of global, collaborative scientific networks. The comment of one of the experimental group participants is interesting in this context; ‘I have been on several overseas science trips, but I wasn’t able to study much science. However, this time I learned new things, developed, and strengthened my desire to study’. As the social networking training was the only major difference between the two groups, it suggests network awareness has a number of previously unexplored benefits.

The findings suggest that short-term study abroad programs would benefit from including units related to social skills training. Explicit didactic instruction on differences in social expectations along with active learning techniques such as role plays, small group discussions, and self-reflection have deeper and more meaningful experiences studying overseas.

5. Limitations

While the data suggests that didactic material and activities regarding networks of collaboration can make study abroad programs more successful for Japanese high school students, there are some limitations to our findings. It is possible that the experimental group provided more answers related to scientific networks of collaboration because they understood the expectations of the projects. It could be that the control group would have provided more similar answers if they had received similar prompting about the reason for the international exchange experience. Although there were differences between our control and experimental groups, replication with larger samples and random assignment is needed to confirm the effects of the added training. Future studies would also benefit from including a standardised pre and post-test Likert-scale survey to measure more precisely the perceived benefits for students. It is possible that students already knew and understood the importance of collaborative networks but did not discuss

it in the control group because it wasn't an explicit topic of discussion in their assignments. Future research should also address whether there are long-term changes in participants ability to interact with other scientists as well as identify the change mechanisms.

6. Conclusion

While a case is sometimes made that Japan's lack of English language ability is a nearly insurmountable barrier to succeeding in a globalised world, this project shows that these barriers may not be difficult to surmount. Evidence from this project suggests that using a behavioural approach to teach specific social skills to Japanese high school students helped them to recognize the importance of collaborative science networks as well as to effectively engage with instructors and peers from other cultures to both 'do' science and form collaborative networks.

While science can be defined as a method of creating or discovering new objective knowledge, science is also a social process, one that involves networks of researchers, sometimes from around the world, all working for a shared goal. Future scientists must of course study and train deeply within their chosen fields if they wish to push forth the bounds of knowledge. However, as this project shows, also taking the time to train future scientists to recognize the importance of professional relationships, how collaborative networks form, how to communicate effectively with other people, and how best to use technology to support collaborative research is also important to the health of scientific fields. Our research suggests that it is beneficial to incorporate social training into science programs, especially at a young age. Students should be engaging in scientific activities with their peers, with special attention to project-based learning with international partners, even if only through online tools. This training will prepare students to become international stewards of scientific knowledge creation.

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グローバルな研究コミュニティへの参加：
国際交流、日本の高校生、科学的協力ネットワーク

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要旨：科学的知識は、多くの場合世界中で活動する研究者のチームによって発見されます。研究者は、協力的なネットワークを形成する社会的力学を習得する必要があります。 現在の研究では、日本とヨーロッパの高校生が意図性を持って協力的なネットワークを形成できるように訓練するためのソーシャル ネットワーク分析の使用を検討しています。 学生たちは科学プロジェクトで共同作業をしながら、ネットワークの観点からソーシャル メディア ツールを活用して共同ネットワークを形成する方法を学びました。 学生たちがヨーロッパで出会った後、日本人参加者の学習日記と回想のコーパス分析が、ネットワークワークショップなしで同様のプログラムに参加した別のグループの対照サンプルと比較された。分析の結果、トレーニングを受けたグループは、対照サンプルよりもプロジェクトに対するより高いレベルの理解、より高い有能感、そして多文化環境でどのように交流するかについてより深い洞察を示していることが確認されました。

キーワード: 日本、国際交流、高校、科学教育、ソーシャルネットワーク