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Increasing Japanese Students' Interest in Science by Leveraging Space Program Communication: Exploring Solutions for *Rika Banare*

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Increasing Japanese Students' Interest in Science by Leveraging Space Program Communication:

Exploring Solutions for *Rika Banare*

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Abstract: This study examined if space program communication could be used in addressing the problems of *rika banare* (decreasing interest in science among students), which is one of the biggest educational issues facing Japan. In order to explore its solutions, the research question was posed: Can public relations strategies and tactics increase interest in science among Japanese students in primary and secondary schools by raising awareness of space programs? A total of 1,147 Japanese students and eight Japanese teachers both in Japan and in the U.S. participated in this surveys and focus groups. The study revealed that most of the students (69%) increased their interest in learning subjects—such as science (56%) and math (33%)—after space program lectures were delivered. This also had positive effects on other subjects, including history (26%), sports (22%) and Japanese language (19%). The effectiveness of space programs for building students' motivation for learning was found especially on secondary school students. Among space programs, manned missions had the greatest impacts on learning interest regardless of school grades. It was also revealed that despite the new science curriculum introduced in 2009, the negative trend, namely decreasing interest in science among students as their grade advanced, appeared to be continuing. Further, the study indicated that online technologies—especially social media—could be used to better leverage space programs to increase students' interest in science. Most of the students (46%) in the study obtained information on space from the

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Internet, and more than half of them (59%) had used social media as an information source for space, by accessing websites including YouTube (65%), blogs (22%), Facebook (20%) and Twitter (17%). Combining public relations strategies and tactics including online communication platforms, space programs could bring us a solution for this long-lasting educational issue, by motivating the younger generations to learn science and technology. Expanding the audience in these areas may help secure human resources to maintain and increase Japan's international competitiveness through invention and innovation.

本論文は、理科離れをテーマに、宇宙プログラム（space programs）と広報（public relations）の手法との組み合わせが主として小、中学生の理科への興味関心に与える影響を調べ、理科離れの解決策について論じたものである。日米双方で、1,147 名の生徒と 8 名の教師を対象に定量的調査と定性的調査を実施。宇宙に触れることで、69%の生徒が学習意欲が向上したと回答。理数分野（理科：56%、算数／数学：33%）以外の他分野（例、歴史：26%、体育：22%、国語：19%）を含め、宇宙は学習意欲の向上に広く影響することが分かった。特に、学年に関わらず有人宇宙プログラムの、また、宇宙の分野を問わず中学生への高い効果が見られた。一方、2009 年の学習指導要領改訂等政府、産業界等による様々な取り組みにもかかわらず、学年の経過と共に理科への興味、理解は失われ、理科離れは解消していないことが判明。また、インターネットで宇宙に関する情報を得たことのある生徒（46%）のうち、多く（59%）がソーシャルメディア（SNS。例、YouTube：65%、ブログ：22%、Facebook：20%、Twitter：17%）で宇宙関連の情報を得ていることも分かり、SNS が宇宙や理科に関するコミュニケーションツールとして大きな可能性を有していることがツール別に明らかとなった。インターネットや SNS と共に、宇宙プログラムを広報や教育へ積極的、戦略的に活用することは、理科離れ解消のみならず、科学技術分野における人材確保、ひいては、日本の国際競争力維持、向上にもつながり得ることについて論述。

Key words: STEM, science, technology, interest, space, PR, communication, education, Internet, social media, *rika banare*

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1. INTRODUCTION

Former NASA astronaut Colonel James S. Voss stated before the U.S. Senate Subcommittee on Science, Space and Technology of the Committee on Commerce, Science and Transportation in 2002:

> "I think as you will see when you hear from our students today, space exploration is a powerful motivator for young people, and it is a tremendous tool for teachers. It gets them involved in a hands-on way, they learn from it, and I really hope that they are inspired by it…. The Space Station is such a unique orbiting classroom. It is a laboratory, but it is also a classroom. You are able to demonstrate some things in space that you just cannot do down here. Newton's laws of motion work perfectly up there, and when you show them in space, people really can understand them completely. It is just a wonderful classroom, and we can teach a lot of things from there" (U.S. Senate, 2002, p.16-17).

Rika banare, Japanese for decreasing interest in science among students, is one of the biggest educational issues facing Japan. Previous research reveals that an increasing number of Japanese school children are showing less interest in the sciences. This trend has negatively impacted learning attitudes toward science among the younger generations, and could lead to a shortfall in human resources in these areas in the future (Masuda, 2007). However, current investigation shows that effective solutions are not yet in sight for this issue, especially from the standpoints of interaction between space programs and public relations strategies and tactics (e.g., space program communication and social media). Hence, the research question for this study is: Can public relations increase interest in science among Japanese students in primary and secondary schools by raising awareness of space programs?

This paper will begin with literature review, first by defining *rika banare.* Then, the current situations of, reasons behind and negative impacts of the issue will be analyzed. It will also discuss current efforts to resolve the issue by the government and private sectors. In addition, social media will explored as a critical force to better leverage space programs to increase students' interest in science. Two factors that have dramatically influenced the application of the new communication platform in Japan will be evaluated in the context of space program communication: the March 11, 2011 Earthquake and Tsunami, and the high penetration of broadband Internet networks.

Next, this paper will identify solutions for *rika banare* through quantitative and qualitative research that was conducted with 1,147 Japanese students and eight Japanese teachers both in Japan and the U.S. Research results of the current study will describe the roles and effectiveness of space programs as a potential solution for this educational issue that will lead to securing human resources in science and technology, maintaining and increasing Japan's international competitiveness through invention and innovation. How public relations strategies and tactics—including social media—can be used as a communication vessel to better leverage space programs and increase students' interest in science will also be discussed.

Finally, while noting the limitations of the present study, this paper will discuss the implication of its outcomes for the science and educational communities, as well as opportunities for future research.

2. LITERATURE REVIEW

2.1 The Definitions of *Rika Banare*

In 1923, Edward Bernays (1923), one of the early pioneers in the establishment of public relations practices and principles, described public relations as:

> "Information given to the public, persuasion directed at the public to modify attitudes and actions, and efforts to integrate attitudes and actions of an institution with its publics and of publics with those of that institution" (p. 9).

Implemented proactively and managed properly, public relations strategies and tactics can serve as a driving force to raise awareness and lead to desired behavioral changes among the public, addressing challenges in society. In addition, Dozier et al. (1995) state that while culture shapes public relations, public relations help change culture. The fundamental role of PR is to implement a "call to action," by administering sustained communicative principles that effectively incorporates organizations and the public, based on two-way communication processes and capabilities (Global Alliance for Public Relations and Communication Management, 2010). PR can serve as the connective tissue between organizations and the public by enabling the free communication of new ideas and opinions between the two parties, helping co-create culture.

According to Bauer (2012), objective measures of performance and subjective measures of perceptions of science can be used as the indicators of scientific culture (e.g., perception indicators (knowledge, attitudes, etc.) along with performance indicators (R&D spend, manpower, etc.)). He expresses, "Scientific performance and the mentality of science are mutually supportive; and this mutual support is captured by the old Chinese Yin–Yang symbol (Figure 1). Scientific research fosters a scientific mentality, and that mentality in turn supports scientific research by recruiting youth into careers and by creating respect for the voice of science as a cultural authority" (p. 301-302).

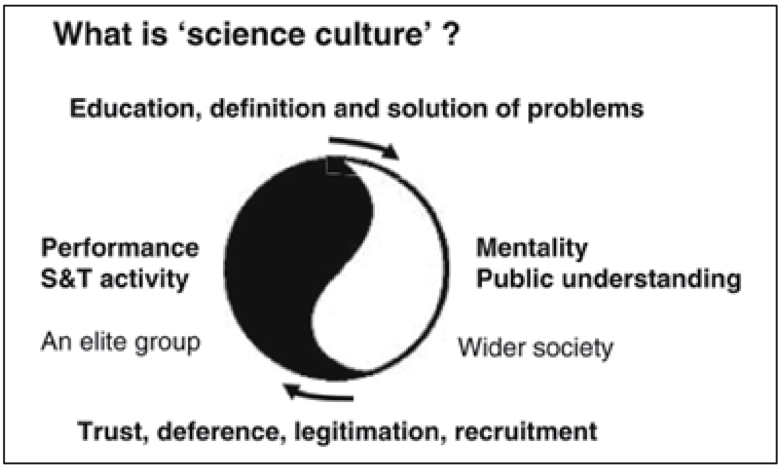

Figure 1. The Yin and Yang of Science: Scientific Performance and Mentality of Science in Society as Mutually Reinforcing Processes.
Note: Source: Bauer, 2012

Arata (2007) states that it is important to understand how many people are asking for science information, not just as a source of technology and economic growth, but as a resource for culture and society.

Scholars have pointed out several reasons of *rika banare*. For instance, Masuda (2007) argues the fact that science is not embedded in Japanese culture is one of the reasons. Additionally, Saito and Takahashi (2005) mention students' decreased motivation for learning as a reason. Thus, this chapter will begin by defining *rika banare,* and analyze the current situations and problems of the educational issue, and then describe current efforts by the government and industry to overcome the challenge.

According to Masuda (2007), *rika banare* can be defined and described as follows:

1. Low interest in, concern on and level of knowledge about science among children.
   Previous surveys have revealed that, as their grade advances, Japanese students lose their interest in science. (Examples, such as data and statistics, will be shown later.)

2. The poor knowledge and understanding of science among the general public.
   According to the *2006 White Paper on Science and Technology* published by the

Japan's Ministry of Education, Culture, Sports and Technology (MEXT) (2006a), the level of understanding of science and technology by Japanese adult people is ranked at 22nd in 25 countries consisting of the U.S., European countries and Japan. In addition, the report shows that more and more people, specifically those under 30, lose their interest in these areas (Figure 2).

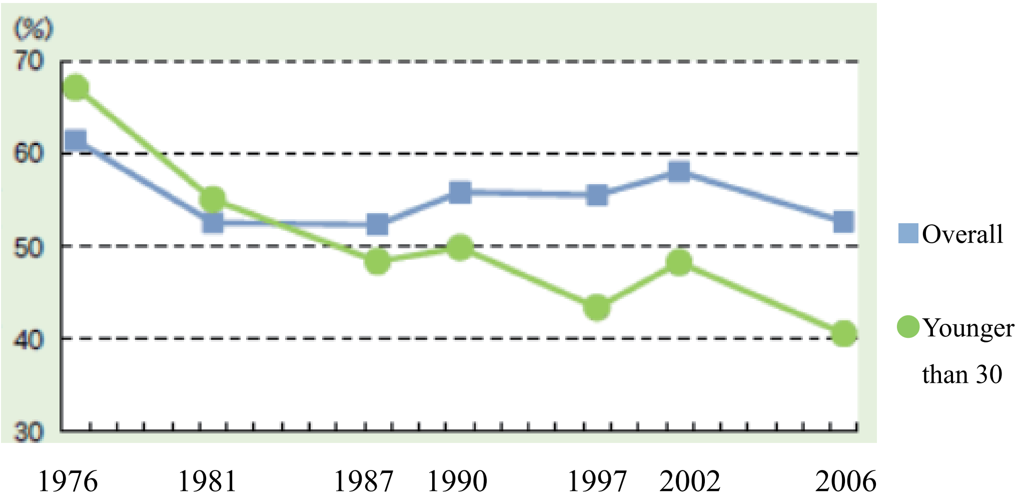

Figure 2. The Percentages of Adult People Who Are Interested in News and Topics on Science and Technology.
Note: Source: MEXT, 2006a

3. Declining enrollment in university science and engineering departments.

More and more high school students choose departments other than science and engineering departments when they make academic career choices. According to the *2006 School Basic Survey* carried out by MEXT (2006b), the number of applicants for engineering departments has decreased by 47% in about a decade: from 574,000 in 1995 to 304,000 in 2006.

4. Deteriorating academic performance in science and math by university students in science and engineering departments.

The curriculum reform in 1994, which reduced the number of required science subjects during high school, is said to have reinforced the decreasing academic achievement in science and math among science and engineering majors. For example, high school students did not have to take physics classes in high school to enter university mechanical engineering departments.

5. Concern about shrinking human resources for science and technology.
   Science and technology are the invaluable sources of invention and innovation, and work as a driving force to spur a country's economic competitiveness. Further, as Japan's median age continues to increase coupled with a declining birthrate, fostering human resources in these areas is critically important to address a variety of issues facing the country, including sustainable development and ensuring international competitiveness with its foreign rivals—especially China and India.

Whichever definition is taken, each shares a sense of danger: as more and more people—especially the younger generations—lose their interest in science, the number of scientists and engineers who will lead the next generation will be reduced, threatening one of the bases of the nation's existence in the future. In addition, the current conditions surrounding science and engineering imply that Japan is lacking the culture that encourages people to embrace these subjects, which are vital to fostering manufacturing technology, invention and innovation. Within this landscape, the nation—specifically the science and educational communities—has been struggling to explore the reasons behind the educational issue, analyze its impacts on society and develop its solutions. In the next section, the reasons and problems of *rika banare*, as well as its countermeasures taken by the government and industry, will be discussed with a focus on school-aged children.

2.2 The Current Situations of *Rika Banare*

While Japanese students have continued to show high performance in math and science tests in international surveys, they enjoy science less than those in other countries as they progress through schooling. According to the OECD's Program for International Student Assessment (PISA), Japanese high school students have high science literacy (OECD, 2009). However, a survey of Japanese school children in the 4th and 8th grades conducted by the International Association for the Evaluation of Educational Achievement (IEA) reveals that the number of students who have positive attitudes toward science fields decreases as their grade in school advances (IEA, 2008). Moreover, their decreasing interest in science is observed by teachers. For instance, approximately 40% of the Japanese secondary school teachers respond to a survey that a growing number of students are disinterested in science (Aoyagi, 2005), and 60% say that the achievement gap in science fields among them is widening (Miyamoto, 2010). Furthermore, the students' misunderstanding of basic scientific knowledge is pointed out as an example of their decreasing interest in science. A report published by Dr. Hidehiko Agata, an associate professor at National Astronomical Observatory of Japan, is one of the visible examples. His report targeted at 4th to 6th graders in Japanese primary schools stunned the science and educational communities by showing the following research results (Agata, 2004, 2005):

- 42% believe in the geocentric theory.
- 53% do not understand the reason of the changing shape of the visible moon.
- 27% do not know that the sun goes down in the west.

To further discuss *rika banare*, the next three sections will describe the reasons and problems of the educational issue, as well as its countermeasures.

2.2.1 Why do students lose their interest in science?

Science is no longer separated from challenging issues in the real world; scientific knowledge is interdependent, collective and emerging from dynamic interactions with reality (Varela et al., 2000). In addition, science education must be relevant to the contexts of our daily life, so that students are better prepared for the challenges and changes in today and the future (Hodson, 2003). As Tan and Kim (2012) express, to equip students with critical thinking and problem solving skills, it is essential to nurture scientific habits of mind, inquiry skills, creativity and interdisciplinary investigations in the contexts of real world. They state:

> "Issues and challenges such as sustainable development, conservation and efficient use of energy and resources, the influence of ubiquitous information and communication technologies, and the ever greater impact of the developments in science and technology in daily life require science educators to rethink the epistemology and pedagogy employed in science lessons today. In the reciprocal relationship between scientific knowledge and the world, teaching science is something more than an instructional activity to transmit content knowledge in the curriculum to students. It is an enactive action to interpret and build relationships between humans and the world through scientific knowledge and methods rather than locating scientific knowledge into an independent realm of cognition from the world. The question is how science education can help build a sound, sustainable relationship among knowledge, humans, and the life world" (p. 1).

However, science teaching is still content-oriented rather than context-bound (Tan and Kim, 2012). Kolstø (2001) expresses, "School science abides in the domain of ready-made science rather than science-in-the-making, and students learn theories, laws, and formulae as the truth of the world out there." The *TIMSS 2007 International Science Report* conducted by IEA (2008) shows that the lack of the relevance is one of the reasons of *rika banare*. The report points out that students may be more attracted to science and motivated to learn it if they recognize science as useful and advantageous to their current and future life (Table 1).

Table 1
The Index of Students' Positive Affect toward Science and Students' High Valuing Science, and Their Science Achievements

Index / Countries	4th Graders		8th Graders		
	High PATS[a]		High PATS[a]		High SVS[a]
	% of Students	Avg. Achievements	% of Students	Avg. Achievements	% of Students
Singapore	75	598	68	586	67
Hong Kong SAR	79	562	60	649	58
US	75	564	54	533	53
England	59	548	56	561	52
Australia	78	534	47	535	42
Korea, Rep. of	-	-	38	586	41
Chinese Taipei	75	564	40	597	35
Japan	81	553	47	574	26
Intl. Avg.	77	485	65	476	66

Note: Source: IEA, 2008
Note: A dash (-) indicates comparable data are not available.
[a] High PATS means that students show positive attitudes toward science, whereas High SVS indicates that students value science (the above data were excerpted from those categorized in "High PATS" and "High SVS" in IEA, 2008).

Table 1 indicates that, although most of the Japanese 4th grade students (81%) have positive attitudes toward science, which is above average across countries (77%), their positive attitudes sharply decline as they move into the upper grade (81%→47%). Further, the data show only about one out of four 8th graders (26%) value the subject, which is the lowest ratio among countries. This implies that students' lack of understanding about science values is a reason of their decreasing interest in science. However, as Kolstø (2006) concludes, science education plays an important role in developing students' understandings of real-life issues, including the concepts of risk and uncertainty in real settings, which helps them recognize the values of the subject. This will be further discussed later.

Financial conditions surrounding scientists and engineers are thought to be another reason of *rika banare*. According to data by Japan's Ministry of Economy, Trade and Industry (METI, 2005), liberal arts majors can earn more income than science majors once they enter the job market. Average lifetime earnings of the former is ¥52 million ($433 thousand) —about the same as buying a house—higher than those of the latter (Figure 3).

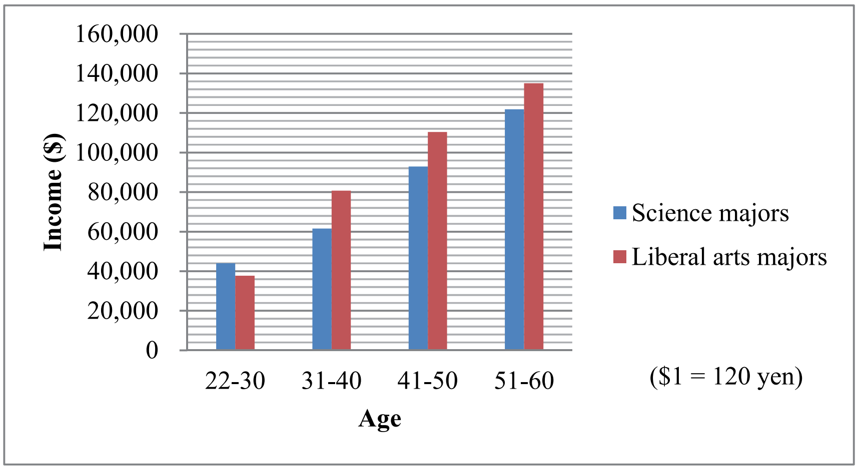

Figure 3. The Average Annual Incomes of Science Majors and Liberal Arts Majors.
Note: Source: METI, 2005

While many students move away from science and engineering departments that do not promise them a financially secure future, the fact that they go to medical school with the intent of earning better incomes is one of the visible examples to imply that the differences in social and financial status obviously impact students' choices of their academic and career paths (Masuda, 2007).

It is also argued, as the third reason of *rika banare*, that students may think math and science are just not "cool." The younger generations—especially female secondary and high school students—are reluctant to become scientists, as they are regarded as "strange" and "nerds" when they say they like science (Masuda, 2007). The peer pressure may dissuade students from these areas.

In 2002, U.S. senator from Oregon Ron Wyden stated before the U.S. Senate Subcommittee on Science, Space and Technology of the Committee on Commerce, Science and Transportation, it was time for action that fostered, not frustrated, students' interest in math and science, and that encouraged them to pursue careers in these areas through an education initiative as a trampoline that could land more students in these areas from which they could find rewarding career paths in a host of professions (U.S. Senate, 2002). "Ultimately, financial incentives or immersion may not be the sole ways to lure the requisite number of students into STEM [science, technology, engineering and mathematics] fields. Finding a way to make math and science 'cool' will be a key to meeting tomorrow's STEM workforce demands.... We should honor science fair students like we honor basketball champions," says James Brown, the executive director of the STEM Education Coalition, a Washington D.C.-based STEM advocacy group (Burnsed, 2011). Teaching dynamic interactions of science with reality is, as pointed out by previous research, also an avenue that should be explored.

2.2.2 What are the problems caused by *rika banare*?

One of the distinctive features of *rika banare* in Japan is that, although Japanese students have less positive attitudes toward science than those in other countries as shown in Table 1, they show higher academic achievement in a standardized science test (Table 2).

Table 2

The Index of Students' Negative Affect toward Science and Students' Low Valuing Science, and Their Science Achievements

	4^{th} Graders		8^{th} Graders		
Index / Countries	Low PATS[a]		Low PATS[a]		Low SVS[a]
	% of Students	Avg. Achievements	% of Students	Avg. Achievements	% of Students
Japan	7	523	25	529	32
Chinese Taipei	11	534	35	527	24
Korea, Rep. of	-	-	36	526	17
Singapore	11	553	13	517	8
England	24	533	25	510	17
US	12	521	24	503	17
Hong Kong SAR	10	522	19	498	9
Australia	11	505	31	494	28
Intl. Avg.	11	452	16	436	11

Note: Source: IEA, 2008

Note: A dash (-) indicates comparable data are not available.

[a] Low PATS means that students show negative attitudes toward science, whereas Low SVS indicates that students do not value science (the above data were excerpted from those categorized in "Low PATS" and "Low SVS" in IEA, 2008).

Table 2 indicates that, even though Japanese students show the high academic achievement in the science test, the ratio of those who have negative attitudes toward science has a greater increase as they move into the upper grade (7%→25%). Further, it reveals that a greater number of them do not value the subject (32%).

As pointed out by previous research, this negative trend has led to decreasing human resources in science and engineering fields. By contrast, it is estimated that in order to achieve an annual real GDP growth rate of two percent, Japan will face a potential shortfall of 160 thousand science researchers and 1.09 million engineers in 2030 (MEXT, 2005). Mobilizing a new generation of science and technology (S&T) experts is a growing challenge in the face of students' reluctance to study these fields for their future careers, which will be a serious problem for economy in the future. This signals an urgent need for substantial nation-building initiatives to resolve *rika banare.* Better understanding of and positive attitudes toward S&T fields must be gained to secure human resources in these areas, foster invention and innovation and maintain Japan's international competitiveness.

Moreover, scientific knowledge and skill are essential in areas other than S&T, such as politics. For example, as argued by Potter (2012), knowledge of science and engineering is a must-have for diplomats in charge of international non-proliferation regimes including the Nuclear Non-Proliferation Treaty, as the knowledge is imperative to fully understand weapons and missiles, better negotiate with other nations and prevent the spread of weapons of mass destruction (WMD).

Both the acquisition of knowledge and its use are equally important in meeting the complex challenges facing the world today. Scientific knowledge is without purpose if it is not shared with those who can use it. The educational community needs to provide students with practical knowledge of science and technology, so that they could see scientific topics in their everyday life, as well as use the knowledge to make their choices and influence other people's actions (Calabrese Barton et al., 2007). Science teachers must begin by teaching students the significance of the socio-scientific dimensions of science, while equipping them with deep understanding of its scientific dimensions (e.g., a biotechnological process has ethical dimensions) (Christensen and Fensham, 2012). Providing a friendly, down-to-earth, approachable and interactive experience would enthuse students about science and scientific careers, as well as inspire teachers (Terrill, 2007).

2.2.3. Efforts to resolve *rika banare* by the government and industry

Japan's strong commitment to education enabled rapid economic growth in the post-war era, and high-quality human resources produced by the national commitment have made the country one of the leading players in the world economy through high-technology and high value-added products and services.

Japan spends on R&D on a percentage basis more than EU and the U.S. It devotes an average of 3.44% of its gross domestic product (GDP) to R&D compared to 2.01% and 2.77% for EU and the U.S. respectively (Claessens, 2012). The investment in science and engineering helped achieve high economic growth from the 1950s to 1970s. Masuda (2007) mentions that, while promoting progressive technical innovations, government policies supported the economic growth. The 1957 plan to expand the pool of human resources in science and engineering fields by MEXT, which aimed to increase the number of scientists and engineers by 8,000 for three years, is one example. Nevertheless, as pointed out by Makino (2007), the younger generations were losing their curiosity about science, a trend which became a public concern in the 1980s. In the late 80s, with the intent of being a world leader in science and technology, the government started taking measures to deal with the issue. Japan faced a dark period for ten years after the bubble economy collapsed in 1991. Nonetheless, the country continued to develop strategies to promote science and technology, exemplified by the Science and Technology Basic Law in 1995 and the Science and Technology Basic Plan in 1996. The government's idea on S&T was shown in the *2003 White Paper on Science and Technology,* including a special topic titled "Science and Technology and Society," that mentioned the importance of communication between the scientific community and society (MEXT, 2003).

Much has changed in Japan since the Fundamental Law on Education was adopted in 1947. The average life expectancy has risen from 50 to 79 years for men and from 54 to 85 for women, which is the highest in the world. The birth rate has dropped from 4.5 to 1.3. Its under-15 population has fallen from 35% of the total population to 13.3%, and the proportion will decrease to 8.6% by 2050. With the decline of the birth rate, the country is facing a "super-aging" society. In addition, the high school attendance rate has grown from 43% to 98%, and that of university has risen from 10% to 49%. While 49% of the workers were involved in agriculture and 30% in manufacturing, now less than 5% are engaged in the former and more than 67% in the latter (Inoue, 2009; OECD, 2012).

In spite of the strong commitment to science and technology, Japan is struggling to get students interested in these fields. The government and industry have been striving with getting them more involved in these areas and addressing *rika banare*. In this section, a series of curriculum reforms by the government will be described first, and then approaches by the private sector will be explained.

The national school curriculum, which is revised every ten years, is the main pillar of the education system in Japan. The curriculum is set by MEXT with advice from the Central Council for Education consisting of educational professionals. While the curriculum is defined as "guidance," schools closely follow its recommendations (OECD, 2012).

Many curriculum reforms have been conducted, mirroring in survey results of students' educational performance and learning attitudes, such as those by international organizations including OECD (OECD, 2012). The curriculum reform in 1996, with the slogan of *ikiru chikara* (zest for living), was a turning point of Japan's education. MEXT applied a new philosophy to education intended to enhance students' ability to think creatively and act autonomously, while emphasizing key competencies, independent thinking and problem-solving skills. Through the reform, MEXT tried to help students develop a well-balanced personality and acquire cognitive and non-cognitive competencies that were vital in Japan's changing economy and society. *Ikiru chikara* emerged as a reaction to the previous educational directive: "strict insistence on uniformity, specificity and direction from the top" (OECD, 2012, p. 190). Complying with the slogan, *yutori kyouiku* (relaxed education) was implemented in 2002 to reduce the intensity of the school curriculum. The volume of primary and lower secondary school curricula was reduced by 30%. This meant that students had fewer opportunities to learn about science. Owing to the reform, science topics—such as the changing shape of the visible moon—were eliminated from the curricula, depriving students of the chance to learn some fundamental scientific facts (Agata, 2004, 2005).

Research results that showed a general deterioration of educational performance and decreasing interest in learning—especially in science—among Japanese students (e.g., OECD, 2004; Agata, 2004, 2005) led to nation-wide doubts about *yutori kyouiku*. Facing the backlash, MEXT began to rebalance the reform, and a new science curriculum was introduced to primary and secondary schools in 2009. The new curriculum not only increases science class hours (by 16% in primary and by 33% in secondary schools) and offers more topics (e.g., the positional relationship of the sun, the earth and the moon; the changing shape of the visible moon), but also emphasizes relationships between science and society to raise students' awareness and understanding of the subject in the context of daily life. In addition, it promotes the use of information and communication technology (ICT) to equip them with further opportunities to obtain information on science, better meet a wide variety of their concerns and needs, and improve their interest in learning (Hyogo Prefectural Board of Education, 2008; MEXT 2008)

The private sector has devoted itself to address *rika banare*. More and more industries are involved in science education for students. For example, according to Council of Competitiveness *Nippon* (COCN) (2011) consisting of world-leading Japanese companies and organizations (e.g., Toyota, Toshiba, Sony, Canon and the Mitsubishi group), the number of science education support activities (e.g., lectures on science and engineering, training of teachers and factory tours) has increased tenfold since 2001, and 200,000 science education programs were conducted in 2009 by the council members. However, as pointed out by the council, these activities rely heavily on school teachers and their interest in and understanding of the companies' education programs. It is also pointed out that the relationships between the companies and schools are often extinguished after the teachers moved to other schools (COCN, 2011). In addition, venture companies have also entered into science education activities. Leave a Nest, a Japanese company founded in 2001 with 44 employees (as of March 2012), is one of the examples. The company provides teachers and students with a variety of lesson modules, including educational programs and experiment kits. Since its foundation, more than 10,000 children have taken its science workshops (Leave a Nest, 2012).

Despite the efforts of both the public and private sectors, the *2012 National Survey of Students' Academic Performance and Learning Conditions* reveals that many students lose their interest in science as their grade advances, and that *rika banare* is still a big issue

(MEXT, 2012). It also shows that students' attitudes toward science are more negative than toward other subjects, such as Japanese and math (Table 3).

Table 3

Changes in Positive Attitudes toward Science, Japanese and Math

	Primary School Students			Secondary School Students		
	Science	Japanese	Math	Science	Japanese	Math
I like to learn the subject.	82%	63%	65%	62%	58%	53%
It is important to learn the subject.	86%	93%	93%	69%	90%	82%
The subject will be useful in the future.	73%	89%	90%	53%	83%	71%

Note: Source: MEXT, 2012

Note: % means the ratio of students who answered "agree a lot" or "agree a little" to each statement.

Table 3 shows that an increasing number of students dislike studying science and recognize its importance and values less when compared to other subjects. The study also reveals that students who have a preference for observation and/or experiment, as well as those who go to schools that teach on observation and/or experiment, show higher academic achievement in science. This test result warns that the science and educational communities should further devote themselves to resolve the educational issue. Students equipped with scientific knowledge and practice are essential resources that will lead the world's next generation and sustain world development. It is a crucial time for Japan to regain students' interest in science, by creating more proactive and effective science communication policies, strategies and tactics to address *rika banare*.

2.3 The Potential of Social Media in Education in Japan

ICT is an indispensable set of tools that allow organizations to proactively and effectively interact with the public. The implication of digital networks can be observed at almost every corner of the earth. Especially, social media makes it possible for information and ideas to be exchanged with anyone in the world with Internet access. The use of new communication platforms and two-way communication enabled specifically by social media are vital for organizations to open lines of interaction, foster creativity and co-create values with a wider audience, meeting its diverse concerns and needs.

According to Japan's Ministry of Internal Affairs and Communications (MIC), today nearly 80% of the population (approximately 95 million people) in Japan uses the Internet (MIC, 2012a). In addition, social media has become widely used as a staple of communication since the March 11, 2011 Earthquake and Tsunami. In spite of its values, the science and educational communities have not yet embraced the new communication platform to their full potential. Therefore, how social media could be used as a countermeasure for *rika banare*, as well as its opportunities and challenges in education, will be explored in this chapter.

2.3.1 The impacts of the March 11 Earthquake and Tsunami

The March 11 Earthquake and Tsunami revealed the power of social media to Japanese people, dramatically increasing its users in the country.

At 14:46 on March 11, 2011, the 9.0 magnitude earthquake rocked Japan. The biggest earthquake and subsequent tsunami in Japanese history caused catastrophic damages in eastern Japan (Figures 4, 5). People lost communications, as the phone networks were knocked down due to damaged telephone stations in devastated areas and overwhelming demands for calls that flooded phone lines across the nation (Saito, 2011). However, the Internet, especially social media that used servers abroad, was relatively unaffected (Yokoyama, 2011). Therefore, people were able to use data services and text, and began communicating on Twitter and Facebook. These communication vehicles helped them connect with their families and friends who were unsure of their whereabouts, and let their loved ones know if they were okay. At that moment, Japanese people found the immense power of these communication tools as a connective tissue in times of crisis. The implications of social media seen during the natural disaster will be discussed to show how it was used then and has penetrated as a communication channel among the people since then, by focusing attention on three tools: Twitter, Facebook and YouTube.

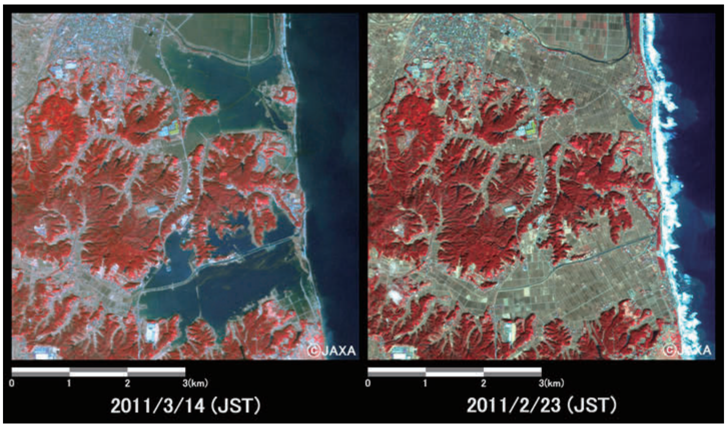

Figure 4. A Satellite Image to Show the Impact of Tsunami in Fukushima (Left: after March 11, 2011; Right: before March 11, 2011).
Note: Source: JAXA, 2011

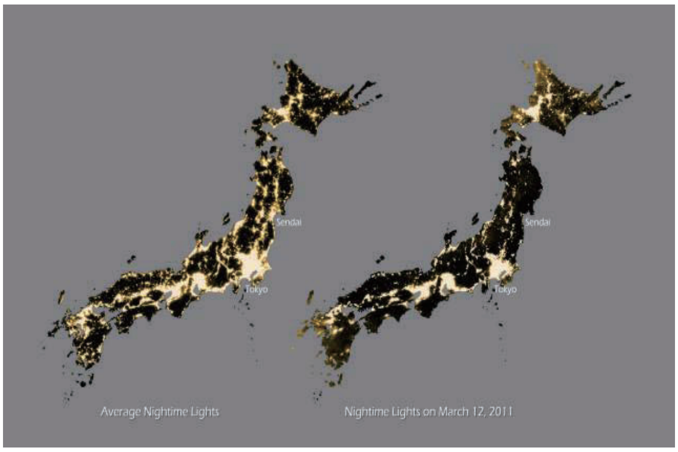

Figure 5. A Satellite Image to Show the Power Shortage in Japan (Left: before March 11, 2011; Right: after March 11, 2011).
Note: Source: NOAA, 2011

Twitter was one of the most widely-used tools at the time of the crisis. Within one hour after the quake, the number of tweets from Tokyo topped 1,200 per minute (Figure 6). For users in Japan, Twitter posted a guide in Japanese to help them communicate with their loved ones. The guide also included earthquake-related hashtags to lead them to special sections where they could obtain updated information on the crisis. One of the most used hashtags globally in 2011 was #japan (Twitter, 2011). Since then, Japan has, according to Semiocast (2012), become the world's third largest market for Twitter with estimated 35 million accounts (Figures 7, 8).

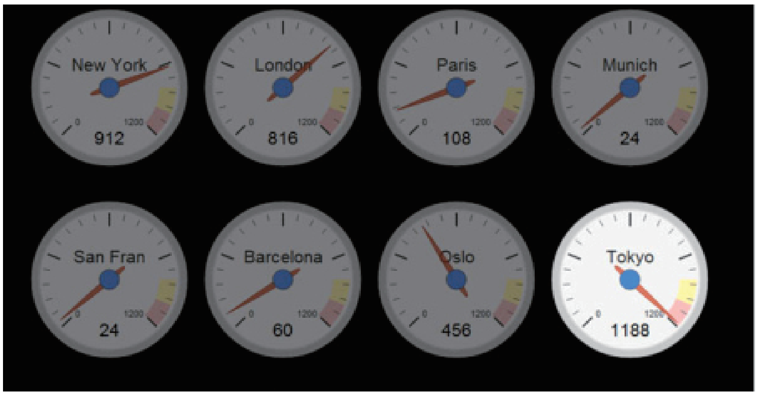

Figure 6. The number of Tweets from Tokyo on March 11, 2011.
Note: Source: Taylor, 2011

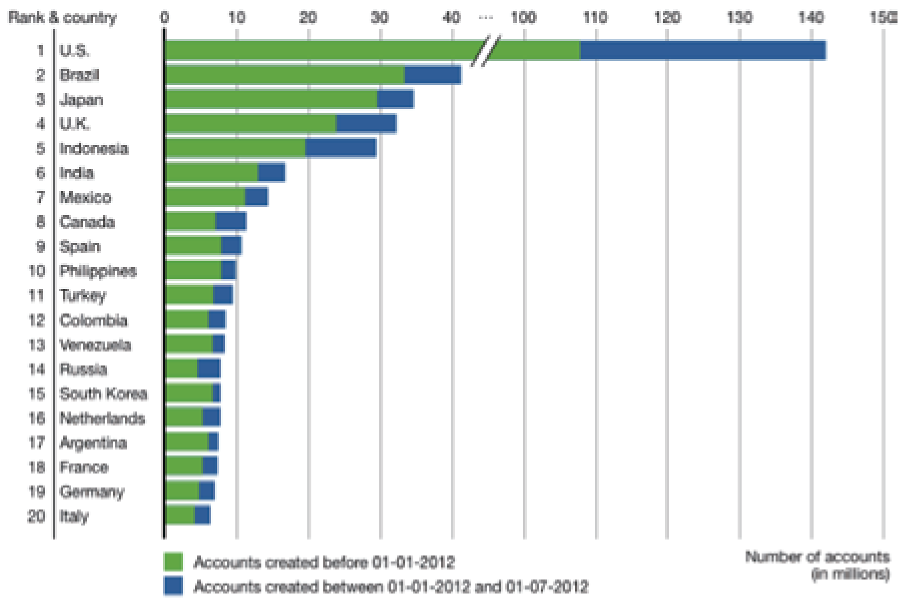

Figure 7. The Top 20 Countries in Terms of Twitter Accounts.

Note: Source: Semiocast, 2012

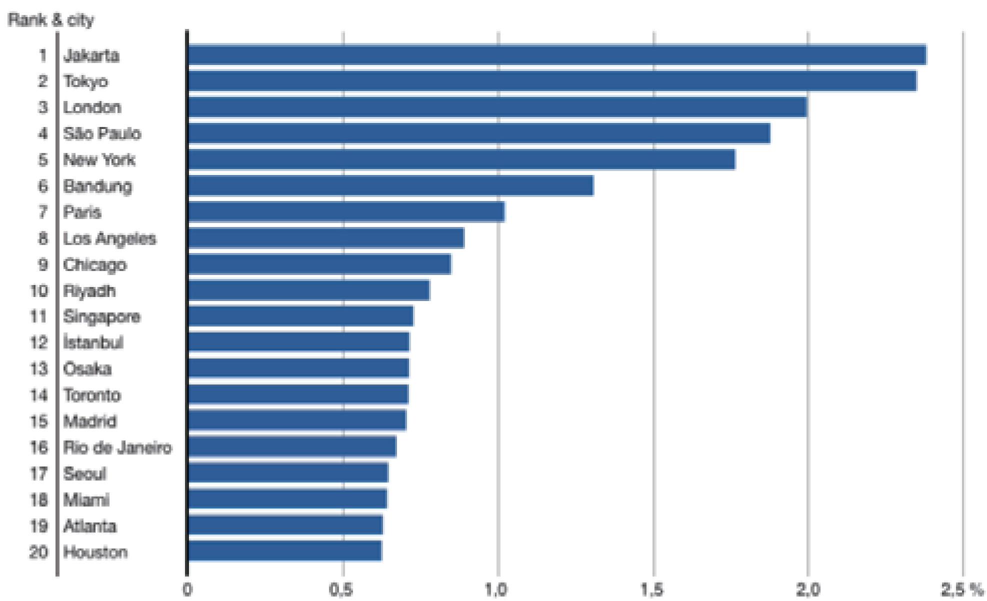

Figure 8. The Top 20 Cities by the Number of Posted Tweets (Among 10.6B Public Tweets Posted in June, 2012).

Note: Source: Semiocast, 2012

Facebook also played a vital role in connecting people. Before March 11, 2011, it was suffering from flagging adoption in Japan, because Japanese people were allegedly reluctant to use their real information (e.g., real names) online. However, Japanese Facebook visitors have been dramatically increasing since then. According to NetRatings Japan (2011), a research firm affiliated with the Nielsen Company, the number of visitors per month surged up by five times in one year: from 1.93 million in 2010 to 10.83 million in 2011, which dramatically raised awareness of the tool among Japanese citizens (Figure 9). This is because they found the benefits of using real information during the crisis. For example, real names helped them identify their families and friends. If they had used pseudonym, they could not have found and communicated with each other. In addition, Facebook provided its users worldwide with digital ways to donate to victims in Japan, such as facebook.com/redcross.

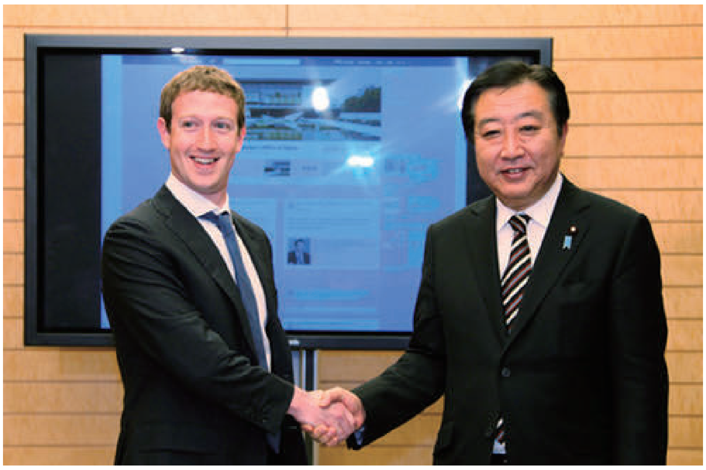

Figure 9. Facebook CEO Mark Zuckerberg's Visit to the Japan's Prime Minister on March 29, 2012.
Note: Source: Cabinet Secretariat, 2012

YouTube allowed people to share the scenes of the quake and tsunami, not only domestically but also globally. As of the afternoon on March 11, 2011, 16,000 earthquake- and tsunami-related videos were uploaded on the platform (ABC, 2011). Millions of people watched the credit-card-size version of broadcast TV on their computers and mobile phones. Owing to a YouTube video, a Japanese international student at the University of California learned her family was alive. She watched a 45-second video of her home in

Minami-sanriku, one of the hardest-hit areas by tsunami in Miyagi Prefecture, and of her older sister on the balcony of her home holding a sign saying, "*Watashitachi wa* (we are) *zen-in* (all) *buji desu* (safe)." She said that it was the only way to hear her family's voice (CNN, 2011). These examples show the power of social media in times of crisis. However, it also reveals harsh realities. Just after the quake, a Japanese businessman was watching a YouTube video in his office. The movie showed a home that was floating on tsunami. And, he said, "That's my home" (Kurokawa, 2012).

The record-breaking disaster has revealed the potential of social media, dramatically increasing its users in Japan.

2.3.2 High Internet and mobile penetration

The increasing use of the Internet and mobile phones, based on the world's top-class speed of broadband networks penetrated throughout almost every corner of the country, has significantly impacted communication in Japan.

In the decade of 2000 to 2010, worldwide Internet and mobile-user population expanded from 390 million to 2.03 billion and from 720 million to 5.36 billion respectively (MIC, 2012b). Similarly, Internet and mobile users have been increasing in Japan. One of the differences from other countries is the high speed of the Internet. The high penetration of optical fiber networks (Fiber to the Home: FTTH) that offer ultrahigh-speed Internet connections enables Japanese people to communicate large volumes of data and enjoy a wide variety of content (Figure 10). In addition, the high mobile-Internet penetration ratio, backed by the widest coverage of 3G networks in the world, allows the people to communicate over the phone almost no matter where they are located (Figure 11).

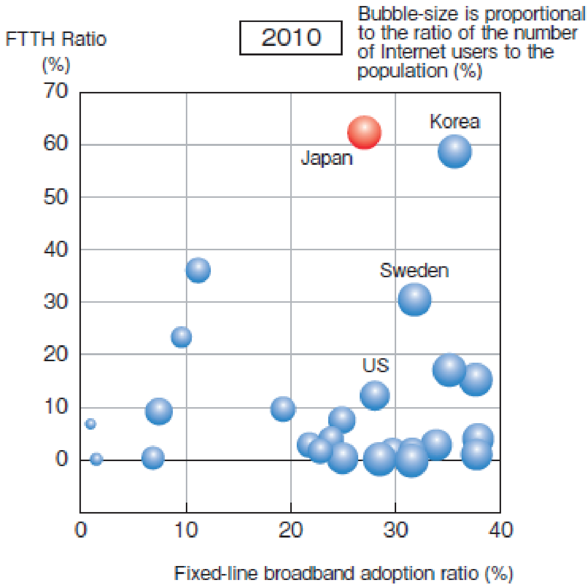

Figure 10. Fixed-line Broadband Penetration Ratio, FTTH Ratio, and Personal-user Population Ratio.
Note: Source: MIC, 2012b

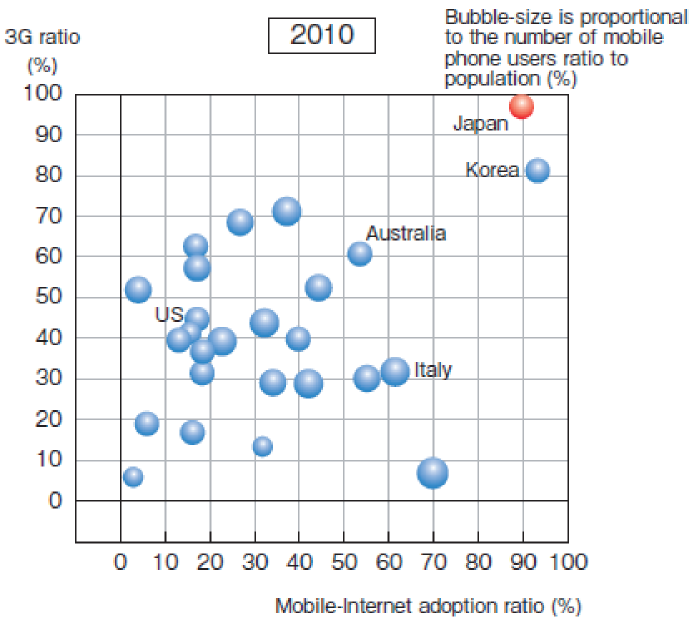

Figure 11. Trends in Mobile (Mobile-Internet, 3G, Mobile Phone) Penetration.
Note: Source: MIC, 2012b

As of October 2012, the number of mobile phone subscriptions in Japan is 132,746,100, which is more than its population: 128,057,000 (Telecommunications Carriers Association, 2012; MIC, 2012c). The increasing speed and penetration rate of mobile phones enable more and more people to access social media from their devices. For example, 66.7% of the smart phone subscribers use social media, while 47.6% of the PC users do the same (Impress R&D, 2012). With this trend, social media—especially Facebook and Twitter—has been expanding its market share in the country (Figure 12).

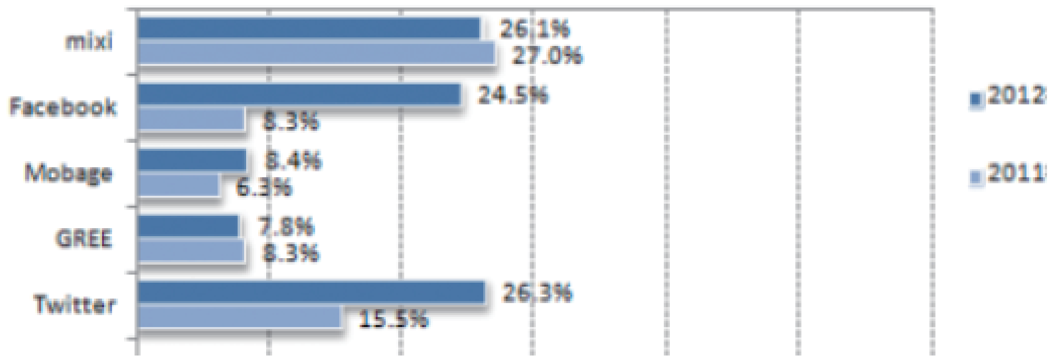

Figure 12. The Ratios of Social Media Users among Japanese People.
Note: Source: Impress R&D, 2012

2.3.3 Opportunities and challenges

As noted above, the new science curriculum introduced in 2009 emphasizes that the application of ICT at school is invaluable to increase students' opportunities to obtain a diversity of information, better meet a wide variety of their concerns and needs and boost their interest in learning (Hyogo Prefectural Board of Education, 2008; MEXT, 2008). In the digital age, ICT is indispensable to advancing science education and improving student gains (Hackling & Prain, 2005; Lee, 2010). Digital connectivity helps learners obtain information based on their preference from a variety of sources, make discoveries and create their own ideas, potentially bringing more creativity in the curriculum (Becta, 2008). Students can learn science from multiple sources of information, ranging from hands-on investigation to Internet searching (Goodrum and Rennie, 2007). Murcia (2012) says:

"Science as a discipline is multimodal, that is, it involves the negotiation and production of meanings in different modes of representation ranging from descriptive text, experimental, to figures and images. Lemke (1998, p .1) argued that multimodal representations of concepts were central to learning science. He stated, 'We need to see scientific learning as the acquisition of cultural tools and practices, as learning to participate in very specific and often specialised forms of human activity'. To understand the values, language and practices of science, children need to experience multimodal representations and explorations in the classroom" (p. 228).

Multimodal representations motivate learners and lead them to a deeper understanding of the subject being taught (Ainsworth, 1999), and Internet technology provides them with multimodal approaches to science learning.

The high penetration of the Internet and mobile phones across Japan is a huge advantage for Japanese school-aged children. OECD (2011) states, "Access to ICT is important, as students' use of ICT for learning partly depends on the extent to which they can gain individual access to a computer" (p. 150). At home, more and more Japanese students have computers, and their access to the Internet has been increasing at a rapid rate (Tables 4, 5).

Table 4

The Percentages of Students Who Reported Having a Computer at Home in 2000 and 2009

Countries	2000	2009	Changes between 2000 and 2009
Hong Kong[a]	94.5	99.0	4.5
Korea, Rep. of	85.7	98.9	13.2
Australia	91.4	98.8	7.4
Germany	87.0	98.8	11.8
France	65.8	96.7	30.9
United States	82.8	93.5	10.7
Japan	67.4	88.7	21.3
OECD. Avg.	72.3	94.3	21.8

Note: Source: OECD, 2011

[a] Hong Kong is a partner country of OECD.

Table 5
The Percentages of Students Who Reported Having Access to the Internet at Home in 2000 and 2009

Countries	2000	2009	Changes between 2000 and 2009
Hong Kong [a]	84.8	98.0	13.2
Korea, Rep. of	62.0	96.9	34.9
Australia	67.4	96.0	28.6
Germany	40.0	95.8	55.8
France	27.1	92.2	65.1
United States	70.0	89.3	19.3
Japan	40.1	81.5	41.4
OECD. Avg.	44.7	88.9	44.2

Note: Source: OECD, 2011
[a] Hong Kong is a partner country of OECD.

Likewise at school, the ratios of Japanese students with access to computers and the Internet are rising. OECD (2011) shows that the percentages in 2009 are 88.6% (cf. the OECD average: 93.1%) and 83.8% (similarly, 92.6%) respectively. In addition, Japan's computers-per-student ratio has been highly increasing among OECD countries (Figure 13), which is the evidence of substantial investment in ICT resources at school.

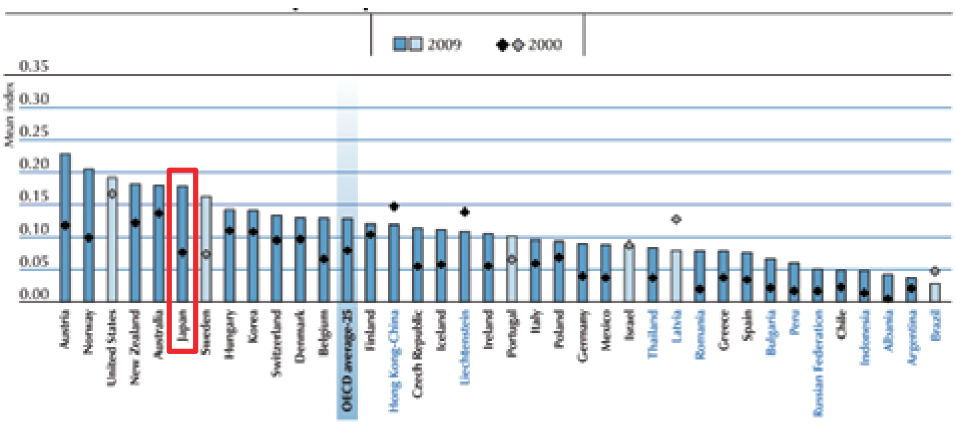

Figure 13. The Ratios of Computers to the Number of Students in School in 2000 and 2009.
Note: Source: OECD, 2009

Applied proactively and effectively, the Internet can have significant positive impacts on education. The research conducted by Agata (2004, 2005) revealed that more than half of the primary school children understood the Copernican theory, which was not included in the former curriculum, and that they might obtain information on astronomy outside of school from sources, such as TV, newspapers and the Internet.

As Bransford et al. (2000) note, learning is enhanced when learning opportunities are tailored to an individual's interests, needs and current levels of readiness. ICT helps customize class materials to each student, while creating a variety of content. "Schools needed to be more data driven, create digitized content for students to use, teach outside the classroom using technology such as online classes, [and] customize education for each student," says Joel Klein, a former New York City public schools chancellor (Koebler, 2011). "Human communities and cultures are," Lemke (2012) states, "often more interesting for what is unique to them than for what they all have in common…. One of the important properties of any class is precisely the specification of how the members of the class differ from one another" (p. 1480). Carefully designed, Web 2.0 technology could serve as a catalyst to provide far more learning opportunities for both students and science teachers. Luehmann and Frink (2012) illustrate the opportunities and benefits of the new communication technology (Figure 14).

Reform-based science goals	NML affordances
Engaging students in: • Collaborative investigations over time • Productive public communication of ideas and work	Prioritizes: • Participation in developing global community • Collaboration • Distributed knowledge
Enabling students to: • Provide evidence-based argumentation and explanations. • Analyze and synthesize data and defending conclusions	NML are: • Openly authored, placing the requirement for evidence on the author • Situated practices in both the type of technology and the way it is used • Transactional processes that invite experimentation and pushing boundaries • Multiple, multimodal, and multifaceted
Students develop: • Understandings, abilities, and values of inquiry. • Knowledge of science content	Requires: • New social practices, skills, strategies, and dispositions for their effective use

Figure 14. Linking Science Education Goals with New Media Literacy (NML) Affordances.
Note: Source: Luehmann and Frink, 2012

The Internet has revolutionized the communication landscape. The younger generations read science news on websites, blogs have come into fashion, and scientists and engineers convey information directly to the public through online platforms. According to Luehmann and Frink (2012), students feel that online tools, such as blogs, help them better understand course materials and develop a sense of ownership of learning. In addition, this new connectivity encourages voices not often heard in classrooms (e.g., typical non-speakers), enhances participation and fosters classroom community, which maximizes learning benefits.

Online communication has, as scholars point out, brought diverse advantages not only for students but also for teachers. For example, online technology equips teachers with a unique window into students' thinking, as customized experiences for students enabled by the technology help reveal their personalities and individual preferences (Luehmann and Frink, 2012). In addition, digital tools help reduce the burden on teachers, as the tools make it possible for them to obtain a variety of educational materials easily and timely, explain subjects and topics visually and vividly, and meet different interests and needs of students through personal experiences, while ensuring a quality of science education (COCN, 2011).

Web technology not only enhances the interactivity between students, teachers and science learning resources, but also shortens the distance between them and scientists and engineers. Terrill (2007) states, “The public, including students, regards scientists as being ‘not quite like us’ and the research they do ‘behind closed doors’ is viewed with some suspicion” (p. 191). The personal aspects of online interactions, especially those enabled by social media, are an innate strength of the Internet. Through direct interactions based on online platforms, an institution can provide the audience with human viewpoints, developing a closer tie between the two parties. As Crough et al. (2012) express, online technology helps bridge the gap between how students conduct science at school and how science is conducted in real settings, as well as integrate school curriculum into a variety of resources that could not be obtained without the technology. Hofstein and Lunetta (2004) agree that the orientation of science teaching towards interactive elements can nurture students’ learning. This is also supported by other scholars, such as Lazarowitz et al. (1996), showing that the interactive elements positively influence students’ cognitive and motivational learning outcomes. An “open door” between the world of scientists and engineers and outside groups helps establish a direct connection and promote interactions between the two parties, making complex scientific information accessible to a wider audience. Applied strategically and tactically, ICT can maximize the values of hyperlinked and multimodal online resources, broaden the community and audience, and create more opportunities for students to engage with peers, teachers and outside scientists and engineers. Bauer and Bucchi (2007) state, “Making information, originally prepared by experts for other experts, available beyond the specialist circle enables patient groups to become significant actors for other patients on medical issues, multiplying and mixing the types of material available to the general public” (p. 4). While this statement is about medical issues, it can be applied to scientific issues.

Seitel (2011) states public relations is a planned process to influence the attitudes and actions of a target audience. As discussed above, PR strategies and tactics—such as space program communication, ICT (e.g., social media) and tailored experiences that the technology makes possible—have huge potential to better leverage space programs as a vehicle to inspire students' intellectual curiosity, stimulate their interest in learning and resolve the decades-long educational issue: *rika banarte*. Thus, the research question was posed: Can public relations increase interest in science among Japanese students in primary and secondary schools by raising awareness of space programs?

In order to explore the answer to the research question, quantitative and qualitative research was conducted with 1,147 Japanese students and eight Japanese teachers. In the next chapter, the details of the methods will be described.

3. APPROACHES TO INCREASE STUDENTS' INTEREST IN SCIENCE BY LEVERAGING SPACE PROGRAM COMMUNICATION

New York University adjunct professor Paul Oestreicher expresses in his book, *Camelot, Inc.*:

> "Experiences become a growing network of wired connections that enable us to utilize the knowledge from a past situation and make good decisions in a different circumstance" (Oestreicher, 2011, p. 21).

Shared experiences and knowledge created between the science and technology communities and students help the next generation address challenges they will face in society, enrich their lives and create a better world, while stimulating their interest in learning.

As previously stated by former NASA astronaut James S. Voss, experience and knowledge of space exploration is a powerful motivator for the younger generations, as well as a tremendous educational tool for teachers. It inspires students, stimulates their interest and urges them to explore the world of learning. Space programs offer classrooms and homes invaluable opportunities to develop their intellectual curiosity (U.S. Senate, 2002). Therefore, space program communication, based on public relations strategies and tactics including those related to online technology, may be an important element in inspiring their intellectual curiosity, improving their learning attitudes and resolving *rika banare*.

Science education is critically important, as technological advantages brought by science are also economic advantages. If Japan does not invest in science education, these advantages will be lost. As engineering discoveries and the development of the Internet have contributed to the exponential growth of the world economy in the last decade (U.S. Senate, 2002), scientific invention and innovation will continue to work as a driving force to spur a country's economic competitiveness. This is of utmost importance to ensure Japan's international competitiveness with its foreign rivals, as well as to address challenges facing the super-aging country. Developing the talents and skills of science and engineering for students is an imperative to drive its economy.

However, as pointed out by many scholars, past science communication professionals have paid little attention to public relations (e.g. Arata, 2007; Elias, 2007; Pantarotto & Jori, 2007; Terril, 2007; Kobayashi et al., 2009; Okamoto et al., 2009). Considering the current situations surrounding Japan's educational scene, the space community may have a crucial role in helping develop solutions for *rika banare* in collaboration with the educational community.

Edward Bernays et al. (1955) argues, "Any person or organization depends ultimately on public approval, and is therefore faced with the problem of engineering the public's consent to a program or goal" (p. 114). In addition, Arata (2007) states starkly, "No public awareness, no money" (p. 174). The fruits of space programs should not only be in the hands of scientists and engineers, but also those of the general public including students. The space community should take trailblazing roles to inspire public interest in science and technology through their unique missions, while raising the awareness and understanding of its activities among the public. In addition, by educating and marshaling the next generation in the pursuit of S&T, the space community will be able to deepen its roots in R&D and reach for new stratospheres in these areas.

Former NASA administrator Sean O'Keefe said, "It is imperative that the next generation be motivated and considered as the opportunities for the continuation and the quest of exploration and discovery in math, science, technology, and engineering as pursuits in disciplines within their college pursuits" (U.S. Senate, 2002, p. 5). As noted by then-U.S. Senator Sam Brownback (R-KS), "Capturing the imagination and spirit of grade school students is the first step to ensuring the longevity of the technical field…. To do this we must give them something to get excited about, which is one of the key roles that NASA can play" (U.S. Senate, 2002, p. 3). Aerospace organizations have important roles to play in this endeavor through the promotion of scientific research, exploration and education programs, as science education is vital to the future of the general public as well as of the organizations themselves. Japanese aerospace organizations—such as the Japan Aerospace Exploration Agency (JAXA), the only Japanese governmental aerospace R&D

institution—are no exception in this regard, and should proactively accept their responsibilities of inspiring and stimulating the next generation to explore the science world, as stipulated by Japan's Basic Space Law established in 2008. In the law, the roles of the space community are stated in Article 21 and Article 22:

> Article 21. In order to promote space development and utilization, the State shall take necessary measures for securing, training and enhancing the qualifications of the talents in the fields of space development and utilization, while collaborating with other entities such as academia and the private sector.
>
> Article 22. In order to improve public understanding and raise its awareness of space development and utilization, the State shall take necessary measures for promoting education and learning and enriching public relations activities relating to space development and utilization, while collaborating with other entities such as academia and the private sector.
> (p. 8)

The Basic Plan for Space Policy developed in 2009 further describes the responsibilities of the space community in Chapter 3 2. (7):

> 2) Promotion of child education and public relations to appeal the lure of space
> Educating young people who lead the next generation to gain right knowledge and understanding about space is important in expanding the base of human resources engaged in the future use and R&D of space and maintaining continuous support of Japanese people for promotion of the space development. The following measures and policies will be promoted in collaboration with local educational institutions by promoting the projects to appeal children responsible for the next generation and utilizing the activities by the JAXA's space education center:
>
> (a) Expansion of opportunities for real experience and simulated experience
> ・ Field trip to the facilities at launch sites during sightseeing and school excursion
> ・ Enhancement of opportunity to meet with astronauts and scientists
> ・ Utilization of science museums and [the] Internet

(b) Enhancement of space education

- Support for educational material enhancement
- Utilization of vital power of private sectors and various groups

(p. 55-57)

As regulated in the law and plan, JAXA is required to extend its intellectual resources to a wider audience, such as students, educators and the general public, through proactive and proficient communication.

Previous research demonstrates that *rika banare* is still a big issue in Japan. By contrast, space programs, as pointed out by aerospace and educational professionals (US Senate, 2002; Sahara, 2008), has huge potential to inspire students, stimulate their intellectual curiosity and boost their interest in science. Further, as described above, online communication technologies—especially social media—have been more widely used since the March 11, 2011 Earthquake and Tsunami. This indicates that online platforms will be key channels to convey information and messages about space programs to a wider audience. In short, it is now that proactively and effectively applying research methods and practices, the aerospace and educational communities should jointly explore the effectiveness of space programs and seek the better avenues to communicate the subjects to resolve the decades-long educational issue.

3.1 Research Question

The literature review discussed in the previous chapter clearly shows problems caused by current science education, as well as opportunities in solving them by interconnecting space programs and public relations methods and practices including social media. It implies that the interaction could provide a new avenue to increase awareness of scientific issues among students, positively impact their attitudes toward the sciences and address the educational shortfall facing Japan's society. This has led to determining primary research needed in order to address the central research question: Can public relations increase interest in science among Japanese students in primary and secondary schools by raising awareness of space programs? Thus, with the research question in mind, the following areas were explored in the present study:

(1) What attitudes, opinions and images do students have toward science?
(2) To what extent do students have knowledge of space science?
(3) To what degree does space program communication affect students' attitudes toward science?
(4) From what sources do students obtain information about space science?
(5) What are PR strategies and tactics to efficiently and effectively use space programs to increase students' interest in science?

By seeking the answers to these areas, the effectiveness and roles of space programs were explored. To pursue the answers, lectures on space programs were given to Japanese students at schools, a science museum, a public education center and a community center as a means of space program communication, and then surveys and focus group discussions were conducted. The study was targeted at Japanese school children in Japan and the U.S., which enabled international comparisons. In addition, focus group discussions were performed with teachers, which provided different—sometimes conflicting—viewpoints from those of students. In order to minimize the constraints of fluency amongst the Japanese participants of the study in the U.S., lectures, surveys and focus group discussions were conducted both in Japanese and in English.

The purpose of the study, ground rules (e.g., ethics, confidentiality and voluntary nature of the study) and study design were disclosed to potential participants both orally and in writing. In addition, consent to participate was obtained from the appropriate parties (Appendix A). The methods and practices used in the present study (e.g., data collection and analysis procedures; participants' demographics) will be described in the subsequent sections.

3.2 Quantitative Research

3.2.1 Methods

From September to November 2012, a series of lectures on space programs were given to Japanese people in several cities in Japan and in the U.S. at the request of schools, a science museum, a public education center and a community center. Using these opportunities, surveys were distributed to a total of 1,147 people, mainly consisting of primary and secondary school children.

The primary goal of the questionnaire was to analyze and evaluate the effectiveness and roles of space programs as a solution for *rika banare*. All participants were asked the same questions, which were formulated to address the research question. The questions were mixed in structure: number-based, yes/no and open-ended. The open-ended question allowed the participants to freely express their impressions and opinions, helping develop better solutions for the educational issue.

Lectures were given by several lecturers depending on the locations of the venues. Each lecturer was given necessary information (e.g., the current situations of *rika banare*, the research outline and methods), so that she/he could understand the purpose, significance and procedure of the present study. The content of the lectures was basically same and contained the following elements (see an example of the lecture materials in Appendix B):

・Rockets
・Satellites
・Manned space programs (e.g., astronauts, the International Space Station (ISS))
・Planets and stars
・Space technologies in daily life

The fifth element—space technologies in daily life—was included to show the audience the benefits of science and technology in everyday life and observe the correlation between its understanding of the advantages of and attitudes toward these areas.

Before and after the lectures (in Japan, only after the lectures due to the limited time), the following sets of questionnaires were fielded (see each question item in Appendix C):

・Students' attitudes and opinions toward science, (e.g., "Do you like science?" "Do you think science is useful, helpful, necessary and important for you (for your daily life, for developing your intellectual curiosity, for your study and job in the future, etc.)?")
・Their understanding of space science (i.e., the heliocentric theory or the geocentric theory, the direction of the setting sun, and the reason of the changing shape of the visible moon)
・The impacts of space program lectures on them (e.g., the relationships between space program communication and their learning attitudes)
・Their sources for information on space science (e.g., TV, newspaper, the Internet including social media)
・Their demographics (i.e., age, gender and living area)

The same questions and answers given in the previously-mentioned research (i.e., Agata, 2004, 2005; IEA, 2008), conducted before the science curriculum reform in 2009, were provided in the present study to determine the impacts of the reform.

First, Cronbach's coefficient alpha was calculated to check the internal consistency of the questionnaire, and found to be .756, a "good" score on a scale of unacceptable, poor, questionable, acceptable, good and excellent. The questionnaire was filled in by hand by students at the venues of the lectures, and each answer was transcribed into the Qualtrics survey program (Qualtrics Labs, Inc.). Data were aggregated and classified by location, grade and gender, and cross-tabulation and several statistical analyses were performed to assess the correlations among variables (e.g., grades, genders and interest in science). Comparisons with previous research (i.e., Agata, 2004, 2005; IEA, 2008) were conducted to examine changes in basic knowledge about space and in interest in science among students from the past. Further, using the IBM SPSS Text Analytics for Surveys and Statistics programs (International Business Machines Corp.), answers to the open-ended question were analyzed by text mining and correspondence analyses to detect overall trends, such as the impacts of the space program communication, changes in interest in science and other subjects, and opinions and perspectives on *rika banare* among students. Responses were first categorized utilizing the software programs, and then dendrograms were used to cluster the data into broader categories by comparing, contrasting and questioning the degree to which category labels could best contain each of the subcategories. Finally, 23 categories were created.

3.2.2 Participants' demographics

The Japanese students who participated in this project were chosen from both Japan and the U.S. In Japan, they were selected from large and midsize to small cities to examine the presence of city-size differences. The definitions of city sizes in Japan are based on those by the Statistics Bureau (MIC, 2015). The details of the quantitative research—such as dates, research sites and participants' demographics—are shown in Table 6.

Table 6

Participant's Demographics

Sites	City Sizes/ City Names/State Name		No. of Participants/ Grades/Male-Female Ratios		Dates
Japan					
School	Large City	Tokyo[a]	117, 7^{th} to 9^{th} graders	(100:0)	10/30
		Fukuoka[b]	117, 7^{th} to 9^{th} graders	(0:100)	11/10
	Midsize City	Higashi Osaka	95, 7^{th} to 9^{th} graders	(43:57)	11/17
		Urayasu	76, 5^{th} graders	(50:50)	10/23
	Small City	Munakata	113, 5^{th} to 6^{th} graders	(54:46)	11/18
		Chikusei	182, 5^{th} to 6^{th} graders	(40:60)	11/8
		Hokuto	119, 7^{th} to 9^{th} graders	(52:48)	10/19
Museum	Small City	Kashihara	33, 1^{st} to 9^{th} graders[c]	(75:25)	9/23
Public Education Center	Midsize City	Toyohashi	17, 1^{st} to 7^{th} graders[c]	(47:53)	11/18
Community Center	Small City	Hiki-gun	28, 2^{nd} to 9^{th} graders	(56:44)	11/18
US[d]					
School		New Jersey	93, 3^{rd} to 4^{th} graders	(57:43)	10/13
			157, 5^{th} to 11^{th} graders	(42:58)	11/3
Total			1,147		

[a] Boys' school

[b] Girls' school

[c] Data only on primary and secondary students are shown, while the audience was from kindergartners to adults.

[d] In the U.S. both pre-test and post-test questionnaires were conducted, while in Japan only post-test was done. In addition, focus group discussions were conducted only in the U.S.

3.3 Qualitative Research

3.3.1 Methods

Erickson (2012) argues that qualitative research in education is especially appropriate when we want (1) detailed information about implementation, and (b) to identify the nuances of subjective understanding that motivate various participants in a setting.

In October and November 2012, focus group discussions were conducted after a space program lecture at classrooms in a Japanese language school in the U.S. with its 4th and 8th graders. They attended the school on weekends and learned in Japanese according to the curriculum established by MEXT, while going to local schools on weekdays. These two grades were intentionally selected to compare and contrast with previous research (i.e., IEA, 2008). Participant students with prior consent were chosen by their teachers. The purpose of the discussions was to further explore students' attitudes and opinions about science, changes in interest in science after the lecture, sources for information on space, use of social media, and opinions and ideas on solutions for *rika banare*. Moreover, discussions with teachers, who participated them voluntarily, were performed at the school to hear their opinions and ideas on issues and problems of science education, reveal their concerns and needs for the recent curriculum reform, and obtain their comments and advice on solutions for the educational issue from teachers' standpoints.

Nineteen people were gathered and divided into four groups: two students' groups (4th and 8th graders) and two teachers' groups (primary and secondary teachers). Each group was consisted of three to seven persons, and 25 to 30-minute sessions were conducted by the same researcher. Discussion guides, including questions to the interviewees, were developed to better organize the discussions (see Appendix C). All the discussions were recorded, and selected quotations from the interviews were transcribed.

3.3.2 Participants' demographics

Most of the 4th and 8th graders drawn by their teachers from the audience of the lecture had experience in learning based on both Japanese and American curricula in each country, which enabled international comparisons to be made and led to unique and insightful findings.

The focus groups of teachers, unfortunately, did not include science teachers, as the school did not have science classes. However, as discussed later, their insights, comments and opinions provided this study with informative, insightful and thought-provoking findings. The teachers' variety of backgrounds, especially teaching experience both in Japan and in the U.S. that most of them had, enabled the data to be compared and contrasted with the issues and problems of education in the two countries, which offered valuable clues to solutions for *rika banare*

Participants' demographics are shown in Table 7.

Table 7
Participant's Demographics

State	Dates	Grades	No. of Participants/ Genders	Notes
New Jersey	10/13	4th graders	4 (2 males, 2 females)	
		Primary teachers	3 (3 females)	3 math teachers
	11/3	8th graders	7 (3 males, 4 females)	
		Secondary teachers	5 (5 females)	3 math teachers[a] 2 Japanese teachers
Total			19	

[a] One of them was a primary teacher.

4. RESULTS

4.1 Quantitative Research

The data collected were sorted using the Qualtrics survey program. Participants were first divided into groups, based on their areas, city sizes (i.e., large, midsize and small in Japan) and research sites (e.g., school, museum). The overall responses to key question items in each site are shown in Table 8. Next, in order to analyze differences across the ages, the subjects were divided into another set of groups on the basis of grades (Table 9). Third, inter-correlations between variables were checked (e.g., similarities and differences by grade and gender). Further, text mining was conducted on the open-ended question given in the last part of the questionnaire to reveal overall trends from each of the participants' feedback on attitudes toward science, changes in interest in science and other subjects, and opinions and perspectives on *rika banare* after the lectures. Observing the participants and their responses from a variety of viewpoints led to more age-, gender- and location-specific analyses, helping develop better solutions for this educational issue.

Table 8

Responses to Key Question Items in Each Site

Question Items	Answers	Total		City Sizes/City Names/Grades				
		Responses (M/%)	n[c]	Large Cities		Midsize Cities		Small Cities
				Tokyo (7-9)	Fukuoka (7-9)	Higashi Osaka (7-9)	Urayasu (5)	Munakata (5-6)
Do you like science? (Q1)[a]	1. Disagree a lot 2. Disagree a little 3. Agree a little 4. Agree a lot	2.96	1,121	2.77	2.41	2.50	3.07	3.10
Is science useful, helpful/ necessary, important for you? (Q3-1)[a]	(Same as above)	3.11	1,122	2.97	2.79	2.43	3.47	3.21
Which is correct? (Q4)[b]	1. The earth goes around the sun.	83%	951	92%	83%	82%	79%	77%
	2. The sun goes around the earth.	17%	190	8%	17%	18%	21%	23%
Where does the sun go down? (Q5)[b]	1. South	2%	26	3%	0%	1%	0%	3%
	2. East	16%	183	5%	17%	13%	17%	19%
	3. West	75%	850	90%	79%	78%	79%	68%
	4. I don't know	6%	73	2%	3%	8%	4%	11%
Before today's lecture, were you interested in science? (Q7)	1. No 2. Yes, but a little 3. Yes 4. Yes, a lot	2.58	1,139	2.39	2.18	2.03	2.70	2.64
Do you think today's lecture might increase your interest in other subject(s)? (Q9-1)	(Same as above)	2.20	1,118	1.64	2.03	1.77	2.30	2.10
If you think today's lecture might increase your interest in other subject(s), in which subject(s) have you become more interested? (Q9-2)	1. Japanese language	19%	147	6%	14%	15%	23%	29%
	2. History	26%	201	20%	10%	23%	35%	26%
	3.Arithmetic/ Mathematics	33%	259	41%	25%	29%	39%	25%
	4. Science	56%	437	39%	48%	35%	65%	53%
	5. Sports	22%	172	20%	13%	17%	30%	25%
	6. Music	14%	107	10%	5%	19%	11%	12%
	7. Others	7%	56	8%	23%	2%	14%	5%
Where do you get information on space? (Q10-1)	7. The Internet	46%	518	55%	31%	41%	47%	21%
If you have got information on space through social media before, from which site(s) have you got? (Q10-3)	1. Facebook	20%	62	15%	23%	31%	28%	0%
	2. Twitter	17%	53	28%	15%	28%	22%	0%
	3. YouTube	65%	199	73%	69%	66%	56%	83%
	4. Blog	22%	67	18%	8%	17%	39%	17%
	5. Others	20%	61	33%	8%	7%	11%	0%

Question Items	Answers	Total		City Sizes/City Names/Grades					
				Small Cities		Museum etc.			U.S.
		Responses (*M*/%)	*n*[c]	Chiku-sei (5-6)	Hokuto (7-9)	Kashihara (1-9)	Toyohashia (1-7)	Hiki-gun (2-9)	NJ (3-11)
Do you like science? (Q1)[a]	1. Disagree a lot 2. Disagree a little 3. Agree a little 4. Agree a lot	2.96	1,121	3.15	2.89	3.45	3.59	3.11	3.15[d]
Is science useful, helpful/ necessary, important for you? (Q3-1)[a]	(Same as above)	3.11	1,122	3.29	3.03	3.31	3.41	3.32	3.25[d]
Which is correct? (Q4)[b]	1. The earth goes around the sun.	83%	951	67%	93%	88%	88%	68%	92%
	2. The sun goes around the earth.	17%	190	33%	7%	12%	12%	32%	8%
Where does the sun go down? (Q5)[b]	1. South	2%	26	1%	0%	0%	0%	0%	7%
	2. East	16%	183	20%	11%	6%	6%	11%	23%
	3. West	75%	850	76%	88%	84%	88%	75%	58%
	4. I don't know	6%	73	3%	1%	9%	6%	14%	12%
Before today's lecture, were you interested in science? (Q7)	1. No 2. Yes, but a little 3. Yes 4. Yes, a lot	2.58	1,139	2.82	2.45	3.09	3.18	2.96	2.73
Do you think today's lecture might increase your interest in other subject(s)? (Q9-1)	(Same as above)	2.20	1,118	2.47	1.89	2.97	3.12	2.64	2.48
If you think today's lecture might increase your interest in other subject(s), in which subject(s) have you become more interested? (Q9-2)	1. Japanese language	19%	147	20%	17%	29%	7%	24%	21%
	2. History	26%	201	36%	19%	23%	27%	24%	27%
	3.Arithmetic/ Mathematics	33%	259	38%	38%	45%	27%	40%	29%
	4. Science	56%	437	61%	59%	52%	73%	64%	60%
	5. Sports	22%	172	30%	13%	16%	13%	16%	24%
	6. Music	14%	107	14%	7%	13%	7%	16%	21%
	7. Others	7%	56	5%	1%	13%	0%	0%	4%
Where do you get information on space? (Q10-1)	7. The Internet	46%	518	27%	53%	27%	47%	43%	75%
If you have got information on space through social media before, from which site(s) have you got? (Q10-3)	1. Facebook	20%	62	0%	21%	0%	0%	0%	27%
	2. Twitter	17%	53	15%	24%	20%	0%	0%	12%
	3. YouTube	65%	199	74%	71%	60%	20%	88%	59%
	4. Blog	22%	67	11%	29%	0%	20%	13%	26%
	5. Others	20%	61	4%	16%	0%	60%	13%	28%

Note: The entire questionnaire is shown in Appendix C.

Note: In some cells, the sums do not equal 100% because of rounding.

[a] This question and answers were given to compare and contrast with previous research by IEA (2008).

[b] This question and answers were given to compare and contrast with previous research by Agata (2004, 2005).

[c] There were students who did not answer all the questions; therefore, the total number of respondents can not be 1,147.

[d] In order to compare and contrast with results in Japan (the posttest questionnaire), the data in the U.S. were taken only from the posttest questionnaire, while the same question was asked both in the pretest and posttest questionnaires.

Table 9

Responses to Key Question Items across the Grades

	Q1	Q3-1	Q4[a]	Q5[a]	Q7	Q9-1	Q9-2[b]	Q10-1[c]	Q10-2[d]	*n*[e]
Grades	***M***	***M***	**%**	**%**	***M***	***M***	**%**	**%**	**%**	
1	3.67	3.33	22%	44%	2.44	2.67	38%	11%	100%	9
2	2.75	3.00	0%	25%	2.63	2.29	50%	38%	67%	8
3	3.22	3.13	15%	61%	2.78	2.79	49%	59%	73%	56
4	3.47	3.46	16%	33%	2.98	3.14	66%	60%	80%	50
5	3.20	3.36	26%	31%	2.84	2.51	62%	36%	52%	282
6	3.09	3.27	20%	23%	2.66	2.15	64%	36%	49%	181
7	2.63	2.96	14%	21%	2.42	1.94	51%	42%	63%	195
8	2.65	2.76	9%	16%	2.21	1.88	57%	51%	54%	166
9	2.83	2.92	11%	13%	2.43	1.78	42%	58%	61%	161
10	2.67	2.89	0%	22%	2.44	2.56	29%	67%	67%	9
11	2.80	3.17	0%	14%	1.86	3.00	20%	100%	100%	6
Total	2.96	3.11	16%	25%	2.58	2.20	56%	45%[f]	59%	1,123

Note: The entire questionnaire is shown in Appendix C.

[a] The percentage of incorrect answers

[b] The percentage of those who answered “science”

[c] The percentage of those who answered “the Internet”

[d] The percentage of the participants who had used “social media” among those who answered “the Internet”

[e] There were students who did not answer their grades; therefore, the total number of respondents can not be 1,147.

[f] The percentage is different from that of Table 8 (46%). The aggregate calculation of Table 9 is on a different category from that of Table 8. Table 9 is based on the grade levels, while Table 8 is on the basis of the geographical locations.

First, as shown in Tables 8, 9 and those presented later, the data reveal the negative trend of science education—namely decreasing interest in science among Japanese students—appears to be continuing. Second, they show that students' understanding of space science is not improved appreciably. By contrast, it is clear that lectures on space programs positively impact students' interest in learning. Additionally, it is indicated that online communication technologies—especially social media—have huge potential as a communication vehicle to better leverage space programs.

Students' Attitudes toward Science

In the first set of questions, students were asked about their attitudes toward science, including if they thought that the subject was useful, helpful, necessary and important for them (e.g., for their life, for developing their intellectual curiosity, for their study and job in the future). Table 10 exhibits the correlations between students' understanding of science values and positive attitudes toward the subject. This implies that, if students understand the values of what they are learning, their positive attitudes toward learning can be monitored accordingly.

Table 10

Correlations between Students' Attitudes toward Science and Understanding of Its Values

Variables	**1**	**2**	**3**	**4**
1. I like science. (Q1)	-	.644*	.558*	.695*
2. I am good at science. (Q2)	.644*	-	.443*	.590*
3. Science is useful, helpful/necessary, important. (Q3-1)	.558*	.443*	-	.583*
4. I am interested in science. (Q7)	.695*	.590*	.583*	-

* p<.01 (two-tailed tests)

To the contrary, the present study revealed that positive attitudes toward science were decreasing as their grade advanced. The changes from 4th to 9th graders that consisted approximately 90% of all the participants are presented in Figure 15, 16 and 17. To put an additional lens to see the changes in attitudes toward the subject, cross-tabulation analyses were performed to see gender differences. In order to compare and contrast with *TIMSS 2007 International Science Report* (IEA, 2008), the data collected from 4th and 8th grades were used. The finding was consistent to support that there was a negative correlation between students' interest in science and their grade levels across gender (Table 11).

Q1: Do you like science?

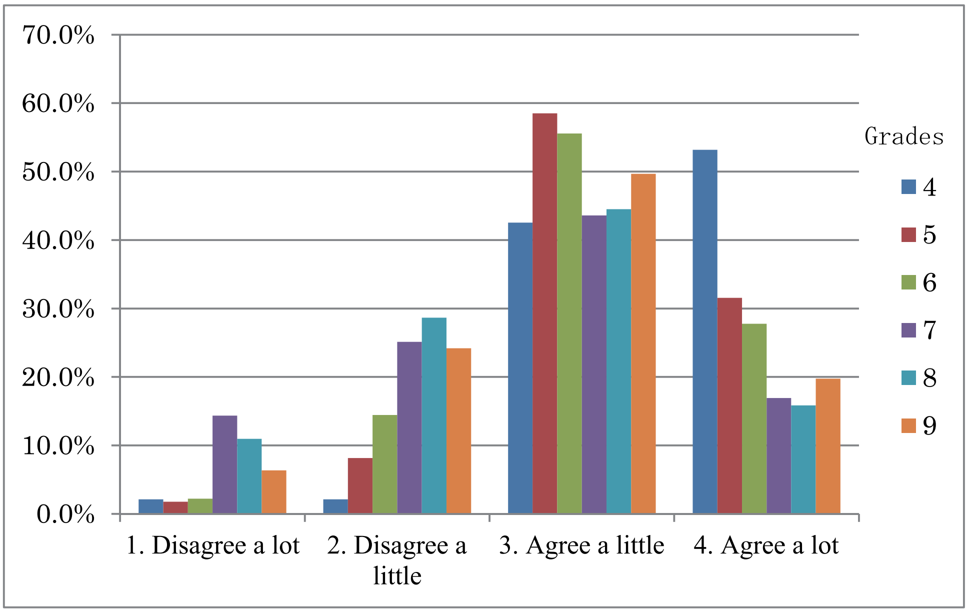

Figure 15. Changes in Students' Attitudes toward Science (Q1: Do You Like Science?).
Note: $\chi^2(15)=123.42$, $p<.000$ (two-tailed test).

Q3-1: Is science useful, helpful/necessary, important for you?

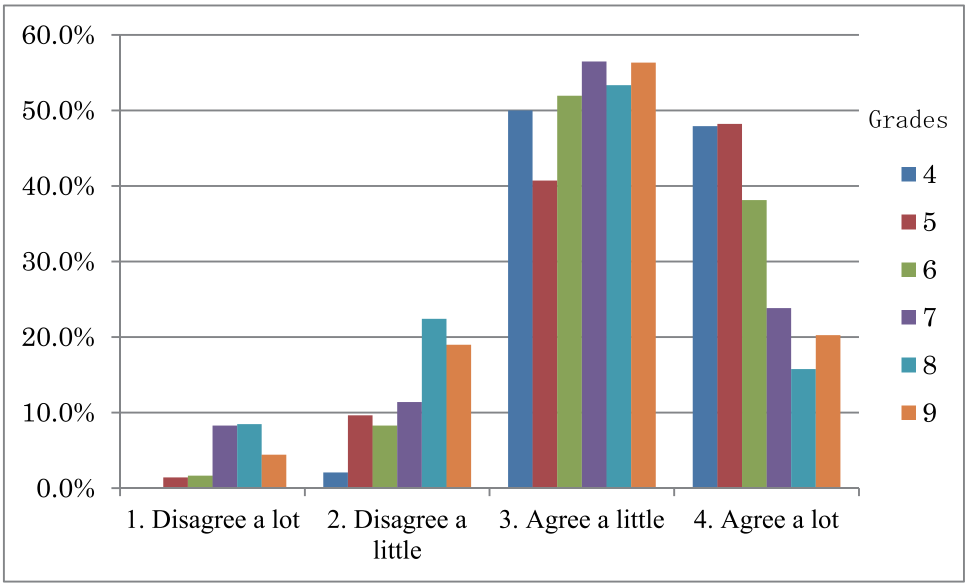

Figure 16. Changes in Students' Attitudes toward Science (Q3-1: Is Science Useful, Helpful/Necessary, Important for You?).
Note: $\chi^2(15)=111.37$, $p<.000$ (two-tailed test).

Q7: Before today's lecture, were you interested in science?

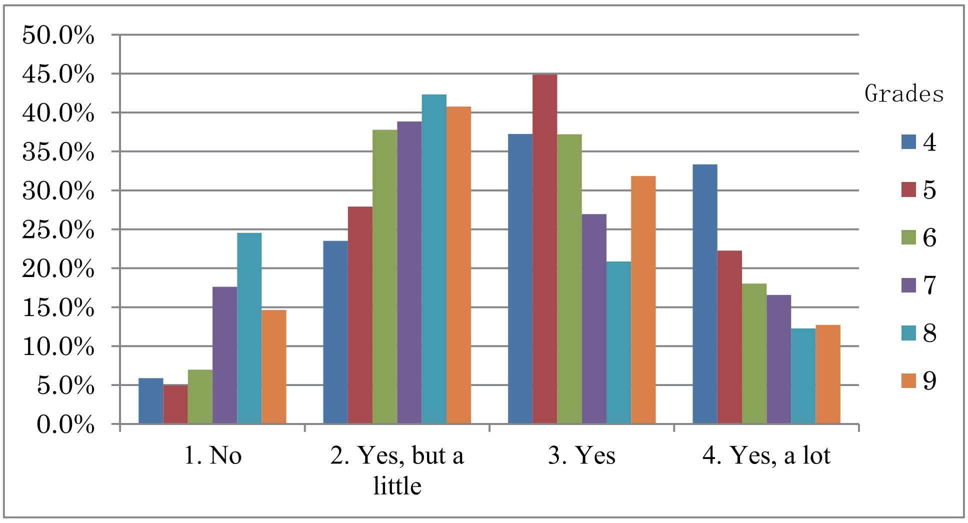

Figure 17. Changes in Students' Attitudes toward Science (Q7: Before Today's Lecture, Were You Interested in Science?).

Note: $\chi^2(15) = 90.70$, $p < .000$ (two-tailed test).

Table 11

Changes in 4th and 8th Graders' Attitudes toward Science

Question Items	Answers	4th graders		8th graders		Differences	
		Boys	Girls	Boys	Girls	Boys	Girls
Do you like science? (Q1)[a]	1. Disagree a lot	3.7%	0.0%	12.0%	10.5%	8.3%	10.5%
	2. Disagree a little	3.7%	0.0%	17.3%	38.4%	13.6%	38.4%
	3. Agree a little	37.0%	50.0%	46.7%	41.9%	9.7%	-8.1%
	4. Agree a lot	55.6%	50.0%	24.0%	9.3%	-31.6%	-40.7%
Is science useful, helpful /necessary, important for you? (Q3-1)[b]	1. Disagree a lot	0.0%	0.0%	10.7%	6.9%	10.7%	6.9%
	2. Disagree a little	3.3%	0.0%	12.0%	29.9%	8.7%	29.9%
	3. Agree a little	53.3%	44.4%	52.0%	55.2%	-1.3%	10.8%
	4. Agree a lot	43.3%	55.6%	25.3%	8.0%	-18.0%	-47.6%
Before today's lecture, were you interested in science? (Q7)[c]	1. No	6.9%	0.0%	20.5%	27.9%	13.6%	27.9%
	2. Yes, but a little	24.1%	23.8%	37.0%	46.5%	12.9%	22.7%
	3. Yes	34.5%	42.9%	23.3%	18.6%	-11.2%	-24.3%
	4. Yes, a lot	34.5%	33.3%	19.2%	7.0%	-15.3%	-26.3%

Note: In some cells, the sums do not equal 100% because of rounding.

[a] $\chi^2(9) = 47.42$, $p < .000$ (two-tailed test)

[b] $\chi^2(9) = 43.16$, $p < .000$ (two-tailed test)

[c] $\chi^2(9) = 32.24$, $p < .000$ (two-tailed test)

Students' Understanding of Space Science

The second set of questions asked students' understanding of space science. They were given the same questions and answers provided in the previous research conducted by Agata (2004, 2005), which stunned the Japanese educational community and led to the curriculum reform in 2009. In the present study, 83% of them chose the heliocentric theory as the correct answer, and 75% answered correctly that the sun sets in the west. It appears that here, at least, the situation has improved. However, if the data on 4th, 5th and 6th graders are extracted to compare and contrast with the Agata's research results, it is shown that the deteriorating condition has not changed appreciably. For example, more than one out of four students (28%) did not know that the sun sets in the west (Table 12).

Table 12

The Students' Understanding of Space Science among 4th, 5th and 6th Graders

Question Items	Answers	Present Study	Agata
Which is correct? (Q4)	1.The earth goes around the sun.	77%	56%
Where does the sun go down? (Q5)	3. West	72%	73%
Why does the shape of the moon change every day? (Q6)	3. The positional relation between the sun and the moon changes as seen from the earth.	60%	47%

Note: Agata's data are also based on the samples not collected randomly.

In addition, an international comparison of the answers to Q5 ("Where does the sun go down?") showed that Japanese students in the U.S. had a lower accuracy rate compared to those in Japan. Forty-two percent of 247 students in the U.S. did not know that the sun sets in the west, whereas 20% of 885 students in Japan answered incorrectly (t=2.53, p<.012).

The Impacts of the Space Program Lectures

The next set of questions focused on the impacts that the space program lectures had on students. This offered important insights, including positive relationships between space program communication and students' interest in learning. Most of the participants (69%) responded that the lectures increased their interest in subjects other than space. Among them, 56% replied that they became more interested in science, so did 33% in math. In addition, the data showed the spreading effects of space programs on their interest in other subjects, such as history (26%), sports (22%) and Japanese language (19%). This implies that, as discussed more later, space programs have huge potential to inspire students, stimulate their interest in learning and put a break on the negative trend in science education.

<u>Students' Sources for Information on Space</u>

In the fourth set of questions, participants were asked about their sources for information on space. Through the questionnaire, the participants provided the following feedback:

1. 46% of the students obtained information on space from the Internet.
2. 59% of those who used the Internet as an information source for space had obtained information on the subject from social media.
3. Among the social media users, YouTube was most widely used (65%), followed by blogs (22%), Facebook (20%) and Twitter (17%).

<u>Students' Perspectives and Opinions on Space Program Lectures and Science etc.</u>

Additionally, participants were given a chance to express their impressions and opinions in the open-ended question in the last part of the questionnaire. Forty-two percent (486) of them used this chance to elaborate on their responses to the multiple choice questions given in the earlier part of the survey. Comments and statements suggesting positive changes in perspectives on space programs were found, such as "I was inspired," "I became more interested in science," "I would like to study subjects more" and so on. Among them, the following are particularly interesting examples exhibiting the effectiveness of space programs as a medium for science communication, as well as some of the challenges the science communication program faces today:

> "I'm so interested in science now. I think today's lecture <u>*will change the way I think about science*</u>, because it <u>*had really good information*</u>." (A female 6th grader)

> "I felt I was not good at science, while I had visited a neighborhood science museum almost every day when I had been younger. Though I <u>*don't have a*</u>

chance to visit there after I entered a junior high school, today's lecture *reminded me of my interest in science* in my childhood." (A female 9th grader)

"I found most of the quizzes in the lecture *could be explained by what I had learned in science classes*, and this was *a good opportunity to review the science lessons*." (A female 8th grader)

"I feel science is interesting, since I *found common technology is used for something both far from me and close to me*." (A male 9th grader)

"I *hate science, but I like space*." (A male 3rd grader)

In order to better represent these open-ended comments and statements, this study employed text mining to breakdown all of them given in textual form and categorize the words/phrases used to build categorical data. This data were then used to carry out a correspondence analysis to exhibit the relations across each category generated from the comments and statements on how students thought about the science communication focusing on space programs. The outcomes of the correspondence analysis show several notable findings.

Figure 18 displays the relations between categories generated through text-mining of answers to the open-ended question. The figure demonstrates that the lectures on space programs wielded a variety of impacts on students. Amongst the categories exhibited in the figure, the lectures were positively received. Furthermore, those categories circled in blue suggest that the lectures gave students both an opportunity and an inspiration to learn more about space and other subjects. Quite notably, the category representing manned space programs (e.g., astronauts and the ISS) made a wide range of impacts on students as indicated by the red lines connecting with other categories that constructively and positively suggested the presence of learning and motivation in learning. In this respect, the subject on manned space programs carries a good potential to craft a pedagogical tool for resolving *rika banare*.

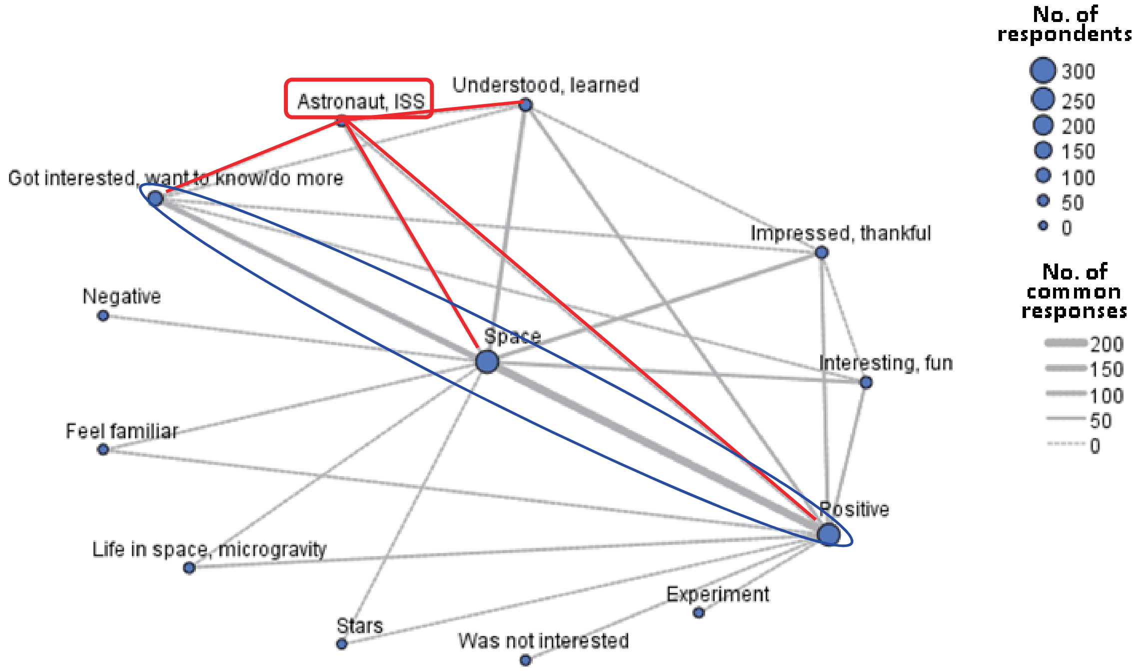

Figure 18. The Text Mining Analysis of Answers to the Open-ended Question.
Note: Categories with less than 20 co-occurrence are not represented in this figure.

Figure 19 is the profile of a correspondence analysis that demonstrates correlations between grades and categories (labels) created from responses to the open-ended question by the 1st to 9th grade students. One of the notable findings is, as seen in the dotted blue circle, that elementary students from the 1st to 5th grades are placed in the forth quadrant where also contains the categories that represent emotional reactions (i.e., "interesting, fun") and positive attitudes toward science (i.e., "like, good at"). This is to say that the students of lower grade levels responded to the lectures on space programs on emotional level, and they had limited ability to make reflective understanding of the subject matter delivered through science communication.

By contrast, the students in higher grade level (the secondary school students marked in the dotted orange circle) are found within the second and third quadrants where categories on pragmatic and practical matters, such as "jobs" and "world-class technology," are shown. It can be said that these students understood the lectures on space programs by making connection to what was familiar and close to their environment. While limited in number, "dislike, bad at" was observed as located within the third quadrant, and it was comprised mainly of reactions to lecturers and their styles, such as "boring" and "too long." This implies that responses from students may differ according to speakers and their ways of speaking.

Furthermore, it is important to note that space program lectures inspired, as circled in red, the interest of students regardless of grades, specifically secondary school students whose decreasing interest in science has been repeatedly pointed out by previous research, and motivated them to learn more. Among 232 students in the 7th, 8th and 9th grades, 43% mentioned “got interested, want to know/do more,” while so did 25% of 253 primary school students (t=4.39, p<.000). This result in the present investigation suggests that space program communication has a solid potential to resolve the long-lasting educational issue—*rika banare*.

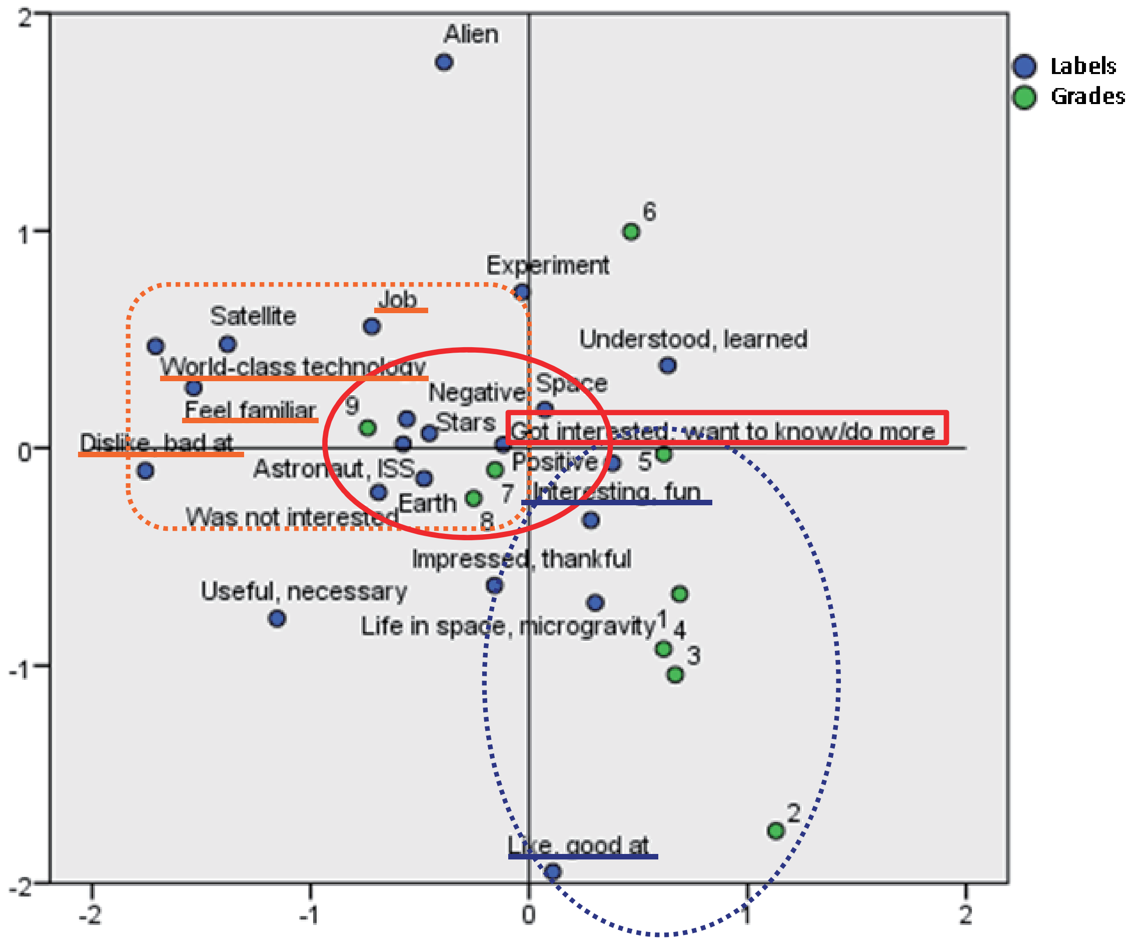

Figure 19. The Correspondence Analysis of Answers to the Open-ended Question.
Note: $\chi^2(264)=342.02$, p<.001 (two-tailed test)

4.2 Qualitative Research

As reported in Table 7, 19 people participated in the focus group discussions. They were divided into four groups: two student groups (two male and two female 4th graders; three male and four female 8th graders), and two female teacher groups (three primary teachers; one primary and four secondary teachers), As shown later, some comments and opinions from students conflict with those from teachers, which gives better understanding of opportunities and challenges in science education.

Students' Attitudes toward Science

First and foremost, the focus group discussions offered insights into students' attitudes toward science, including their changes in interest in the field across the ages. All the four students in the 4th grader group said that they liked science, and mentioned experiments as a reason of their positive attitudes toward the subject. Their responses are consistent with arguments by Japanese scholars, such as Koichi Tanaka—a 2002 Nobel laureate in chemistry—who notes the importance of experiments in science education (Kunimatsu, 2004).

Nevertheless, the next set of discussion showed that students' positive attitudes toward science were diminishing as they moved into the upper grade. When seven students in the 8th grader group were asked if they liked science, their responses were mixed. One male said yes and one female said no. The other five replied that they were neither and it depended on areas in the sciences, whereas two of them responded that they liked experiments. Moreover, a female student who disliked science argued in both English and Japanese, "Physics is obvious. *Datte souiu mon da mon* [that's the way it is]." Her response implies that she thought the subject did not have room to accept new ideas and original interpretations; therefore, it did not seem to her creative, and she could not feel any interest in it. Further, one female student who said neither replied that she felt more interested in science, as experiments became richer as her grade advanced. Additionally, one male (who liked science) and two female (one neither and the other disliked) students responded that their interest in the subject related to the teaching methods of science teachers. One of the female students who responded she disliked science criticized her science teacher's methods, "The teacher is just reading textbooks and makes us fill out worksheets." In addition, another female student who replied neither said that, if teachers made their classes more interesting, students would pay more attention on science. The comparison of key responses from 4th and 8th graders is illustrated in Table 13.

Table 13

The Comparison of Key Responses from 4th and 8th Graders about Their Attitudes toward Science

Ⓜ: Male, Ⓕ: Female

Questions \ Demographics		4th Graders (ⓂⓂ, ⒻⒻ)	8th Graders (ⓂⓂⓂ, ⒻⒻⒻⒻ)
"Do you like science?"	Yes	ⓂⓂ, ⒻⒻ	Ⓜ
	No		Ⓕ
	Neither		ⓂⓂ, ⒻⒻⒻ
"Has your interest in science decreased as your grade advances?"	Decreased	N/A (Asked only to 8th graders)	ⒻⒻ
	Increased		Ⓜ
	Neither		ⓂⓂ, ⒻⒻ
Note			Ⓜ and ⒻⒻ responded that their interest in science related to the teaching methods of science teachers.

<u>The Effectiveness of Space Program Communication</u>

Second, the effectiveness of space program lectures was discussed. Overall, it is clear that space science positively influenced both students and teachers. In the 4th grader group, one of the students explained its positive effect by stating, "Space science gives me chances to make new discoveries." Furthermore, responses from the participants showed its spreading effects. For example, all the four 4th graders agreed that they became more interested in both science and other subjects, such as math and sports. The positive influence was observed from the side of teachers. A Japanese language teacher in the secondary teacher group said that the lecture was interesting. She continued, "Although my students are Americans, speak in English as their first language, do not know about Japan well and said they were not interested in space that much before the lecture, now they say they want to know more about space and science." It can be said from her comment that, while the lecture was given mainly in Japanese, space programs could convey strong messages that crossed language barriers. In her words, a satellite image used in the lecture that showed the night of the earth (see Appendix B) had a spreading effect and told them the message of "peace, happy, and calm," or the preciousness of peace.

The Importance of the Internet and Social Media

Discussions about the Internet offered evidence that online communication tools, particularly social media, were widely used in education. When asked about the names of social media that they had used to obtain information on space, several platforms were mentioned, such as Facebook (by three out of seven students in the 8th grader group), Wikipedia (by two out of four students in the 4th grader group) and YouTube (by one out of seven students in the 8th grader group). The use of online technologies among students was also observed by teachers. They agreed that students widely used the Internet—including social media—to obtain information, study and communicate. According to a Japanese language teacher in the secondary teacher group, students studied in groups using Facebook. To the contrary, a female student in the 4th grader group said, "My parents don't allow me to use SNSs (social network sites)." In spite of the huge potential inherent in social media, her comment shows the importance of parents' understanding of the new communication vehicle.

Differences between Japanese Students in Japan and the U.S.

There was the consensus among the teachers that, whereas Japanese students in Japan were not adept at expressing themselves, were afraid to speak up freely when they did not have the answer and tended to delve into one issue, those in the U.S. had a higher level of self-expression ability and could think from various perspectives. Considering their observation, online tools, including social media (e.g., blogs), could equip Japanese students in Japan with better communication skills. Online platforms, as pointed out by Luehmann and Frink (2012), help students better understand course materials, encourage them to speak up and enhance their participation skills, taking full advantage of learning benefits.

The Impacts of the New School Curriculum

When asked about the new school curriculum introduced from 2009 to 2012, teachers raised several important issues and provided constructive criticism. Both primary and secondary school teachers agreed that due to the new curriculum reform, students were losing chances to learn with enjoyment. A math teacher in the primary teacher group noted the problem of increasing classroom workload caused by the curriculum, and said that the tight course schedule deprived students of opportunities to learn while *asobi* (playing). This comment matches previous studies, such as those performed by Masuda (2007), which point out the importance of *asobi* in education. A Japanese language teacher in the secondary teacher group warned that the new curriculum was making it difficult to foster students' creativity. Further, a math teacher in the primary teacher group mentioned that digital technologies, such as digital content and touch panels, would enable students to study while *asobi,* foster creativity and improve their learning environment.

Participants' Ideas and Opinions about Solutions for *Rika Banare*

Finally, participants' ideas and opinions about solutions for *rika banare* were asked. Although responses from students and teachers sometimes conflicted, this offered a better understanding of opportunities and challenges in science education.

First, from both sides, experiments and firsthand experiences were mentioned. For example, a male student in the 8th grader group argued that, when students learned about plants, they needed to grow a plant to acquire better understanding of what they had learned. Similarly, a Japanese language teacher in the secondary teacher group noted the significance of firsthand experiences, by sharing a story about her primary school daughter who had watched the live broadcast of a space shuttle launch at school and had been moved to tears because she had been so impressed.

Second, it was noted from both sides that educating science in the context of daily life was important. A female student in the 8th grader group voiced strong dissatisfaction with science, by saying that she could not understand why she had to do the math on science tests (e.g., physical calculation), though she did not use it in everyday life. Likewise, a math teacher in the primary teacher group shared her experience to show the significance of communicating science in the context of daily life. While she was just excited about the lecture on space programs and talked about the event to her university and high school children, she opened her eyes to their questions, "Why do people need to go to space and what do astronauts do there while spending millions of dollars?" She did not have answers to these questions; however, she said that she could clearly understand the close ties between space programs and daily life through the lecture, especially through the satellite images of the March 11, 2011 Earthquake and Tsunami that showed damages by the catastrophe from space (she was from Miyagi Prefecture, the hardest-hit area by the natural disaster). If combined with everyday life, she continued, space programs would serve as a driving force to boost interest in science among people, even though they did not have a background in the subject.

Third, a math teacher in the secondary teacher group offered a different viewpoint. She argued from her experience in living with her husband graduated from an engineering department that science majors did not receive favorable treatment in Japanese organizations and companies. She suggested that, if given the image of a better future, more students would go into the sciences as their career paths and more parents would support their decisions.

Last, conflicting ideas and opinions were provided by the students and teachers. While a male student in the 4th grader group and a math teacher in the primary teacher group argued that games (e.g., a money calculation game) were one of the tactics to improve students' interest in science, something that teachers thought interesting was—according to two students in the 8th grader group—boring. A typical example came from a comment given by a secondary female student, "Online games recommended by teachers are tedious, as they have no sense of reality. I hate them!" Her response implies that she felt such games in virtual space were separate from real-world issues, unrealistic and unmeaning. Another conflicting argument was that a math teacher in the secondary teacher group said educating connections between subjects (e.g., geology and math, physics and math) repeatedly would be helpful for students to better understand the wide applications of science and math, as well as the meanings of these subjects. By contrast, the following counterargument by two female students in the 8th grader group is worth noting and evocative for the educational community:

> [Student A]: I can't understand why I have to do the same thing [same or similar topics or lessons] in a science class, while I did it in a math class.

[Student B]: When I am grown, I have to do the same thing [as I did it when I was younger].
[Student A]: Yeah.
[Student B]: I know about space, but teachers say the same thing again.
[Interviewer]: For example?
[Student B]: It's obvious that the earth goes around the sun. If they repeat the topic again, they should delve into it, or expand it. They need to add a twist.

To summarize, the comparison and contrast of participants' ideas and opinions about solutions for *rika banare* are illustrated in Table 14.

Table 14

Participants' Ideas and Opinions about Solutions for Rika Banare

Demographics / Topics	Students		Teachers	
	4th Graders	8th Graders	Primary	Secondary
Experiments & firsthand experiences	Mentioned	Mentioned	Mentioned	Mentioned
Educating science in the context of daily life		Mentioned	Mentioned	Mentioned
Giving the image of a better future in the pursuit of science careers				Mentioned
Game	Mentioned	Mentioned (negative opinion)	Mentioned	
Educating connections between subjects repeatedly		Mentioned (negative opinion)		Mentioned

These research results indicate to the science and educational community the way to go in order to resolve *rika banare*. In the next chapter, this paper will discuss the trajectory of space programs in the pursuit of a solution for the educational issue.

5. DISCUSSION

The Trajectory of Space Programs in the Pursuit of a Solution for *Rika Banare*

Nancy Sato (2003), the author of *Inside Japanese Classrooms: The Heart of Education*, says in her book,

> "Educational excellence may not be quantifiable, but it is instantly detectable…. As one adept American science educator, Doris Ash, explained to me, her goal is to introduce content in such a way that the urge to seek more information is "irresistible." Learners become so intrigued with the problem or issue that they are compelled to do more research to find the answers or to change behaviors and attitudes to help others make progress…. Such moments are the pinnacles of teaching and learning that are educators' greatest rewards. This sense of the "irresistible" is palpable in exemplary classrooms and could be a powerful criterion for judging educational success. Like reading a good book that sparks the imagination and leaves a refreshed feeling, the urge is to want more. The same sense pervades effective professional development that stimulates the desire to return to a classroom immediately to try out a new idea. Every moment will not be rife with compassion or inspiration, but we know when we feel it: a touching of the hearts (*kizuna*)" (p. 246).

This study explores the relationship between space programs and their effectiveness in education, in the pursuit of better use of space programs by applying public relations strategies and tactics (e.g., social media) to resolve *rika banare*. Through the quantitative and qualitative research, the research question, namely "Can public relations increase interest in science among Japanese students in primary and secondary schools by raising awareness of space programs?" was answered with a few limitations as discussed later. The study has shown that space programs touch students' hearts, inspire them and urge them to learn more, while suggesting the potential of online technologies, including social media, as a valid and feasible communication vehicle for space programs.

As mentioned previously, most of the students (69%) increased their interest in learning subjects, such as science (56%) and math (33%). Moreover, as expressed by a secondary school Japanese language teacher in the focus group discussion in the U.S., space program communication bridged the language barrier. Even if her students were Americans and their first language was English, the lecture on space programs given mainly in Japanese could inspire them, increase their interest in science and make them feel a desire to learn more. In addition, the study reveals the spreading effects of space programs on subjects other than science and math, including history (26%), sports (22%) and Japanese language (19%). As a 4th grader stated in the focus group, space programs give people invaluable opportunities to make new discoveries in a variety of areas. Furthermore, as revealed by text mining and correspondence analyses (Figure 18 and 19), space program communication touches students' inner-sense of curiosity and interest, specifically those in secondary school, and will serve as a solution for the long-lasting educational issue—*rika banare*. Therefore, it has been shown that space programs have considerable positive effects on students' intellectual curiosity and motivate them to learn more, and that space program communication is a relational avenue that should be explored to address the educational issue. In addition, while the declining physical strength of children is raised in the new school curriculum as one of the issues that must be solved (MEXT, 2008), the fact that space programs increased students' interest in other subjects—such as sports—has revealed that space program communication has enormous potential to overcome a variety of challenges facing Japan.

By contrast, the study has suggested that despite the new science curriculum, decreasing interest in science among school-aged children appears to be continuing, and *rika banare* is still a big issue. It needs to be noted that 5th graders and below have not learned about the positional relationship among the sun, the earth and the moon. However, it is revealed that one out of four students (25%) does not know where the sun goes down (36% of the 5th graders and below, and 18% of the 6th graders and above), and that almost half of the students (42%) do not understand the reason of the changing shape of the visible moon (56% and 33% respectively). The direction of the setting sun is taught in the 3rd grade, and the reason of the shapes of the visible moon was introduced to the curriculum for 6th graders in 2009 reflecting the previously-mentioned research result conducted by Agata (2004, 2005) that shed light on the lack of the fundamental knowledge of space science among students. Nevertheless, compared to the previous research (e.g., Table 12), the situation has not appreciably changed and further efforts should be sought to solve the problem.

The relationship between the understanding of science values and attitudes toward the subject is another notable finding from the present study (Table 10). Dr. Andrew Hacker (2012), a co-author of *Higher Education? How Colleges Are Wasting Our Money and Failing Our Kids—and What We Can Do about It*, wrote in *The New York Times* article:

> "We need people to understand how those things work and to advance our frontiers…. What is needed is not textbook formulas but greater understanding of where various numbers come from, and what they actually convey. What of the claim that mathematics sharpens our minds and makes us more intellectually adept as individuals and a citizen body? It's true that mathematics requires mental exertion. But there's no evidence that being able to prove $(x^2+y^2)^2 = (x^2-y^2)^2 + (2xy)^2$ leads to more credible political opinions or social analysis…. I hope that mathematics departments can also create courses in the history and philosophy of their discipline, as well as its applications in early cultures. Why not mathematics in art and music—even poetry—along with its role in assorted sciences? The aim would be to treat mathematics as a liberal art, making it as accessible and welcoming as sculpture or ballet."

Although the argument above is about mathematics, this can be applicable to science more broadly. The voice of strong dissatisfaction with science by the 8th grader in the focus group has clearly shown that, as scholars note, educating science in the context of daily life is a potentially effective way to gain more understanding of the subject. As Ramsden (1992, 1994 and 1997) argues, students' interest in and enjoyment of science lessons are generally increased when they engage in context-based courses, which make the learning of science more meaningful for them. These courses strive to achieve an in-depth understanding of science instead of the conventional coverage of scientific content. This may enhance learning and shorten the distance between science and students, increasing their satisfaction with the subject (King and Ritchie, 2012). Claessens (2012) discovers that showing—rather than telling—the younger generations how science and technology impact them through transnational and coordinated science programs will be a key element to stimulate intellectual curiosity and boost interest in science among them. Equipping the next generation with the awareness of socio-scientific issues and the sense that science plays a variety of roles in society is an important task for the educational community (Christensen and Fensham, 2012). The present study has suggested that positive attitudes toward science and the better understanding of its values are interrelated. Consequently, communicating space programs in the context of daily life could serve as a key function to help students better understand science values, inspire their intellectual curiosity and enhance their learning attitudes.

Through examining the use of the Internet among the participants, numerous findings were gained that could be applied to better leverage social media in space program communication. The present study has shown that most of the students (46%) obtain information on space from the Internet, and more than half of them (59%) have used social media as an information source for space, by accessing websites including YouTube (65%), blogs (22%), Facebook (20%) and Twitter (17%). Linda Cureton, the then-Associate Administrator and Chief Information Officer (CIO) of NASA, expresses, “Digital relationships are as legitimate as real relationships” (NASA, 2011, p. 3). The new communication platforms provide links and tools for the science, technology, engineering and math communities (NASA, 2011). As described in the previous chapter, social media has huge potential as a connective tissue in Japan, especially since the earthquake and tsunami on March 11, 2011. If applied strategically and managed properly, these tools could significantly expand the audience of space programs (e.g., students) and improve its learning attitudes.

Japan’s Basic Plan for Space Policy (2009) describes, as previously mentioned, the responsibilities of the space community for the promotion of public relations and child education to increase the appeal and lure of space. It states that equipping the younger generations with right knowledge and understanding about space is important in expanding the base of human resources engaged in science and technology fields. To make this happen, the following measures are suggested in the Plan:

- Expansion of opportunities for real experience and simulated experience
  E.g., field trip to the facilities at launch sites, meeting with astronauts and scientists, utilization of science museums and [the] Internet
- Enhancement of space education
  E.g., educational material enhancement

(p. 56-57)

Through questionnaires and focus group discussions, it has been shown that experiments, firsthand experiences and the understanding of connections with real life are important to maintain and increase students’ interest in science. As stipulated by the

Plan, field trips to aerospace facilities, meetings with astronauts and scientists and educational material enhancement are examples of the tactics. However, not all students can benefit from these opportunities. Equal opportunity is of utmost importance for education. Internet technologies have the potential to balance these two issues. By examining the data collected, the evidence that shows online technologies are a big part of students' lives has been strengthened. Online platforms, including social media, help connect students with people and information that they could not meet in a classroom. King and Ritchie (2012) note that an important part of learning in science is to link contrived classroom activities to events in the real world. For example, blogs and live online interactions with scientists and engineers could be some of the choices, as they help students directly communicate with these professionals, understand intricate scientific and technological issues, and see inside facilities and obtain behind-the-scenes access without actually being there. Additionally, these digital networks could promote dialogues, not only between the professionals and the students but also among the students themselves. By learning from peers and their uniqueness through the interactive platforms, students could be equipped with new ideas and original interpretations of science, better understand course materials and enhance participation skills, fostering classroom communities. Hence, social media could, as revealed by the present study, serve as a communication vehicle to better leverage space programs, offering solutions for a variety of issues in Japan including *rika banare*.

Furthermore, the present study has raised the concern of the lack of an interesting, relevant and challenging curriculum for students, and identified the need to provide quality curriculum resources for teachers. New science materials, including the proactive use of information and communication technologies, need to be developed that focus on the personal and practical relevance of science to students. This will also give teachers the basis for educating science that helps them engage with students in meaningful ways. As Crough et al. (2012) note, computer-based learning environments provide an opportunity to adopt different approaches to science education. The criticism from the female 8th grader in the focus group discussion is worth repeating: "It's obvious that the earth goes around the sun. If they [teachers] repeat the topic again, they should delve into it, or expand it. They need to add a twist." Internet technologies, as a connective tissue with the outer world, could bring new ideas into a classroom, enabling teachers to "add a twist."

Electronic networks could also be advantageous for the science community, as they have potential to encourage conversations between scientists and the public in a timely manner, support the flow of science-related information and improve the image of science in society. As written by Claessens (2012), "Communicating research and engaging with the public is more than a priority. It is an obligation…. The ivory tower is no longer an option" (p. 235, 240). In other words, research professionals should keep in mind that their systems operate in a public context. "Communicating is truly an imperative in a democracy, and this applies also to scientific research if one is to build trust and legitimacy for activities funded in great part by the public" (p. 240). Digital networks could be a key to providing the public, including students, with positive images of science as its career paths, by showing what it will expect to be told: what is being done, as well as what happened (Doorley & Garcia, 2011).

However, a comment from a male 9th grader to the open-ended question is worth noting here. This student expressed his concern on privacy by saying, "While Facebook is widely used, I hesitate to use it, since I have to sign up with it using my real name. I hope you use other sites [to make communication about space programs possible]." His concern suggests that the space community needs to make its position on privacy clear and explicit when it applies ICT, particularly social media, as a medium of communication.

In summary, the present study has indicated the effectiveness of space programs, and that communicating space programs through public relations strategies and tactics—such as the proactive and proficient use of ICT—is an inevitable path that should be further explored. Using the fruits of this study, concerted, consistent and holistic approaches to the development of better use of space programs must continue to be sought.

6. CONCLUSION

6.1 The Summary of the Purpose, Results and Significance of the Research

Findings from the data gathered through the quantitative and qualitative research suggest that there exists a positive relationship between space programs and increasing interest in science among Japanese students. By contrast, the present study shows that the negative trend of science education—namely their decreasing interest in the subject—appears to be continuing. It also indicates a path that should be explored to better leverage space programs through online technologies, especially social media, to resolve the decades-long issue. It shows that the proactive and proficient application of online communication platforms could play vital roles in filling the gap between the current educational condition and an ideal situation. Backed by the increasing proliferation of social media, as well as the expanding penetration of high-speed Internet services, it is apparent that the roles of online media will continue to grow in the future. Therefore, using public relations strategies and tactics including new communication technologies, the space and educational communities should proactively and effectively use and raise awareness of space programs in real or near real time, which should lead to desired behavioral changes among students. Space programs delivered by the proactive and proficient use of online technologies could help broaden the target groups that will be engaged in science and technology, foster human resources in these areas, and maintain and increase Japan's international competitiveness through invention and innovation.

These findings may contribute to the existing body of knowledge in interdisciplinary fields, such as the space, science and educational communities. However, a few limitations contained in the present study must be noted.

6.2 Limitations

It is important to note some of the limitations embedded in the present study, mostly due to the time allowed for data collection. This study conducted a short-time observation to evaluate impacts of space programs on students' interest in science. There was a statistically significant increase in interest in science among students after the lectures on space programs. However, it is of course necessary to carry out a survey that measures longer-term impacts of the lectures to determine their effectiveness on students' learning and interest in science in the longer term.

The second limitation arises from the size and diversity of the samples in the present study. The sample collected in the United States comes from only one of the 50 states; and thus this study is not representing the regional diversity of the country. For instance, it is identified that there is a lack of basic knowledge of science among the Japanese students living in the U.S. (i.e., 42% of them could not answer the direction of the setting sun correctly). However, because of the limited sample size and diversity, it is neither possible nor appropriate to make a conclusive argument beyond identifying what was observed within the samples. Although the findings give perspectives, as well as research agenda, for future projects, more research is needed to explore causality behind what was found in this research.

Third, it is important to consider the possibility of sample bias affecting the research findings. Table 8 exhibits that the students listening to the lectures at the museum and public education center generally responded well compared to the students at the schools. The students outside of school settings came to those venues voluntarily, and thus they might have had a higher interest in science. It is also possible that the students coming to those venues had more science-oriented home culture. Moreover, there might have been a socio-economic reason making impacts on the students' reception to the lectures. These factors need to be controlled if this study seeks to make more conclusive arguments.

Fourth, while text mining and correspondence analyses reveal positive changes caused by the space program lectures especially among secondary school students, it is too early to make a conclusive statement. Further analyses—such as pretest and posttest questionnaires and focus group discussions not only in the U.S. but also in Japan—are necessary to search for the reasons behind such changes observed in the present study.

Last, the research results are applicable only to space programs. The outcomes cannot be generalized to other scientific areas. Thus, further research needs to be conducted to see if a similar relationship between students' interest in science and areas other than space programs.

6.3 Opportunities for Future Research

Whereas the present study has revealed the positive effects of space programs on students' learning attitudes and the trajectory of online communication technologies as a potential solution for *rika banare*, it has also raised some issues, questions and opportunities for further consideration.

First and foremost, findings from this study can only be considered in Japanese educational communities; their applicability in other countries is not yet clear. Nevertheless, many of the challenges facing science education are mirrored elsewhere. Dr. Steven Collins at University of Washington says in an interview with the Japan External Trade Organization (JETRO) that declining interest in science among the public—especially the younger generations—is a common issue in advanced countries (JETRO, 2005, 2006; Masuda, 2007). In addition to the aging population, which means an additional need for scientists, young people's decreasing interest in the subject is, as Claessens (2012) mentions, also a societal issue facing Europe. Moreover, Rodriguez and Zozakiewicz (2010) echo a similar concern. Science education, they warn, is becoming an endangered species in the U.S., due to the strong emphasis on literacy skills and standardized tests in isolation from specific content areas. Furthermore, King and Ritchie (2012) argue:

> "A significant global challenge for a future dependent on science and technology is to engage students in science programs that are relevant for the knowledge society. Many current science programs privilege de-contextualized conceptual learning, often limited by a narrow selection of pedagogies that too often ignore the realities of students' own lives and interests" (p. 69).

The outcomes from this study will hopefully inspire further discussion as to the possibility of correlations between space programs and their influences on students in education communities in other countries, while connecting learning and life.

Second, as previously mentioned, investigating relationships between other scientific areas and their impacts on education is also a worthwhile and necessary direction for future research. If a positive relationship is found, the implications of science communication for the educational issue are potentially monumental. In order to observe long-term effects of science communication in a variety of areas, efforts to collect such data through joint efforts by organizations and institutes—such as the government, academia and industry—should be undertaken (COCN, 2011).

Third, the integration of space programs with social media also needs to be further discussed. Detailed planning and programs for space program communication that applies new media must be sought to better deliver information on and messages of space programs to a wider audience. The reach and effectiveness of mobile phones in the realm of space program communication will also be worth exploring.

Fourth, more emphasis needs to be placed on teachers. As Murcia (2012) states, they model and scaffold for students "how to talk and write about science, how to construct diagrams and calculate and how to investigate and inquire in order to develop and make sense of new knowledge" (p. 229). This implies that science education is twofold: student education and science teacher education. Dr. Alfred Posamentier (2012), the dean and professor of mathematics education at Mercy College, wrote to *The New York Times*:

> "The traditional mathematics program gets a bad rap, largely because it is taught by elementary school teachers who have often been shown not to love the subject —which may be reflected in their teaching—and secondary school teachers who are 'forced' to teach to the test, preventing them from making the subject appropriately exciting. Let's give math the proper platform it deserves!"

The same thing applies to science. According to a survey by Japan Science and Technology Agency (JST), approximately 40% of the science teachers do not feel confident in teaching science (JST, 2012). Hence, more research should be conducted to equip science educators with training to better teach science to students (Masuda, 2007). The quality of education is the quality of teachers (OECD, 2012). Training on how to use social media is also important to apply the new technology to education, as 60% of the science teachers at primary school feel weak in the use of ICT (JST, 2012).

Equipping scientists and engineers with communication knowledge and skill (e.g., social media) is another path that should be explored to further convey scientific knowledge to, better engage with, and more gain understanding and support from the public. This could help secure human resources in science and technology fields, enrich R&D activities and make new discoveries.

By taking this study as an opportunity for future research, Japan must further explore the integration of space programs and social media, boost students' interest in science and technology, and ensure that its stock of human capital in these areas remains competitive with those of other countries and economies around the world, such as India and China. Leadership is an important component of any field of endeavor, and the field of science is no exception in this regard (Gallagher et al, 2012). Japan's government and national R&D organizations, such as MEXT and JAXA, must play a leading role in educational reform that applies space programs, including government-driven collaboration with academia and the private sector. Continued emphasis on communication and partnership building across the sectors is of utmost importance.

Since learning outcomes at school are the results of what happens in classrooms, only reforms that are successfully implemented in classrooms can be expected to be effective (OECD, 2012). Proactive and effective adaptation of social media to science education is an inevitable path that should be further explored. By contrast, "It is important to remember, they are 'tools' nonetheless" (Seitel, 2011, p. 392). Technologies are just tools to support or extend learning and teaching strategies. They do not drive the science curriculum; rather, they help enhance learning and teaching at appropriate times. The science and educational communities need "to go beyond simply understanding technological changes and to further understand the impact of the change on learning and teaching. Greater understanding of the impact of digital tools on learning and teaching is required as they have the potential to change the way knowledge is represented…. It is important to understand the specific ways in which technologies… work as a mediating or convergence tool for a wide range of multimodal representational types" (Murcia, 2012, p. 226).

Questions—such as where we are now, and where we should venture—must continue to be asked to overcome the challenges facing society. *Shuhgouchi* (collective wisdom) is a key for the future prosperity of any nation. It is hoped that the present study will cause interest and discussion in the science and educational communities, by providing fresh insights and recommendations to address the educational issue. It should serve as a starting point—by crystallizing *shuhgouchi*, additional exploration must be sought to seek solutions for *rika banare*.

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9. APPENDIX

9.1. A Consent Form

As an example, the following is a consent form from the school in the U.S.

Consent Form for

Thank you for inviting me to lecture on space science, as well as conduct surveys and focus group discussions, to students at your school. To clarify, this letter confirms the understanding of the purpose and conduct of research on how communication about space programs might impact Japanese students' interest in science.

I am a staff member of the Japan Aerospace Exploration Agency (JAXA). While in the United States, I am attending the School of Continuing and Professional Studies at New York University. This research will be conducted as part of my Master's thesis to be submitted to the university with the purpose of evaluating if space program communication can address the educational issue of decreasing interest in science among Japanese school-aged children. As discussed, it is hoped that the educational community could leverage our findings to increase overall interest in a variety of science fields. The thesis might be published.

Your students will be asked to:

- Complete two questionnaires and participate in discussions about your students' attitudes and opinions about science and other subjects.
- The questionnaires, before and after the lecture, will be anonymous and take 5-10 minutes each to complete.
- The discussion period after the lecture will last approximately 30 minutes.

Your students' responses will be audiotaped, but no names or other identifying information will be collected.

Confidentiality will be strictly maintained with the exceptions being that I am required by law to report to the appropriate authorities suspicion of harm to children or to others, and I cannot guarantee that the students will not discuss the project.

There are no known risks associated with this research beyond those of everyday life. Although you and your students will receive no direct benefits, this research may help educators and communicators understand whether space program communication increases Japanese students' interest in science.

Participation in this study is voluntary. Your students may refuse to participate or withdraw at any time without penalty or loss of benefits. For the questionnaires and discussions, your students have the right to skip or not to answer any questions that they prefer not to do.

If there is anything that is unclear or you do not understand about the study or your students' participation, or if you have questions or wish to report research-related problems, you may contact Satoki Kurokawa at

You have received a copy of this consent document to keep.

Permission to Participate

We have read the foregoing information and received an explanation through a meeting with you. We had the opportunity to ask questions about it and any questions that we asked were answered to our satisfaction. We consent voluntarily for our students and their parents that our students participate in this research study.

10/10/2012

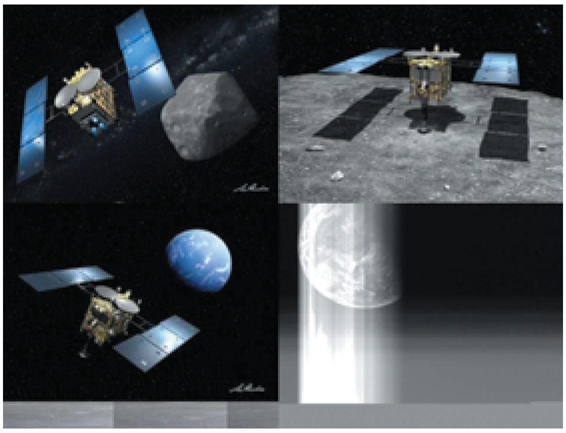
Signature & Date

9.2. A Presentation Material for a Lecture on Space Programs

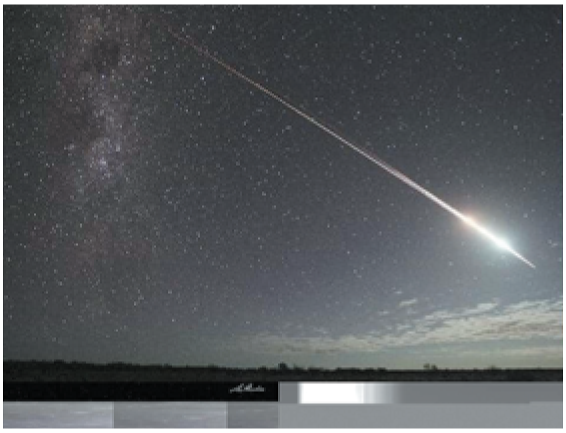
As an example, the following is a PowerPoint presentation material used in the U.S.

Front page

H- II A rocket

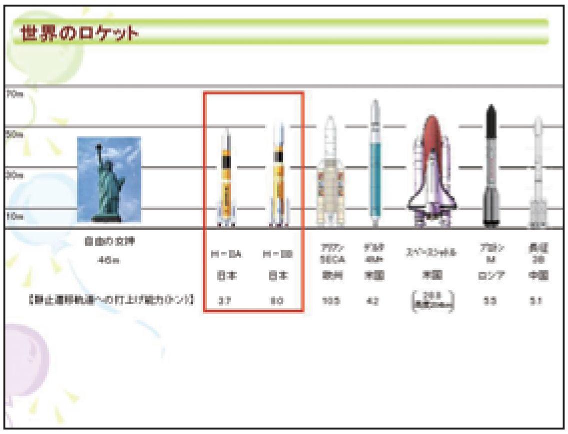


Hayabusa (an asteroid explorer)

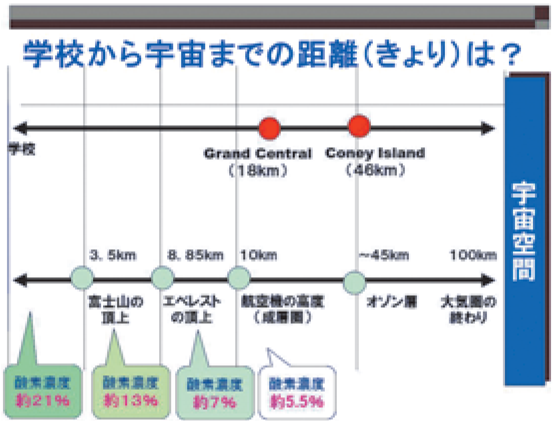


Hayabusa's return to the earth

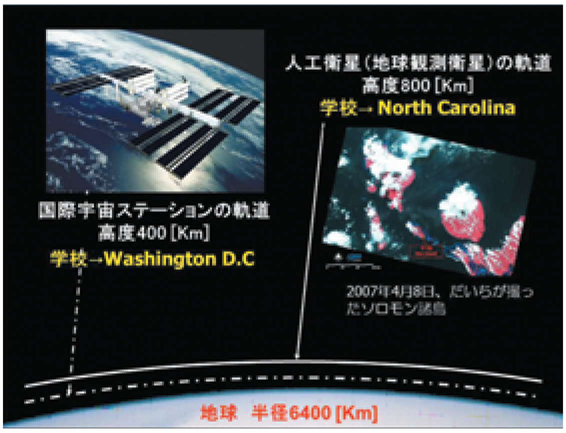
Japanese astronauts



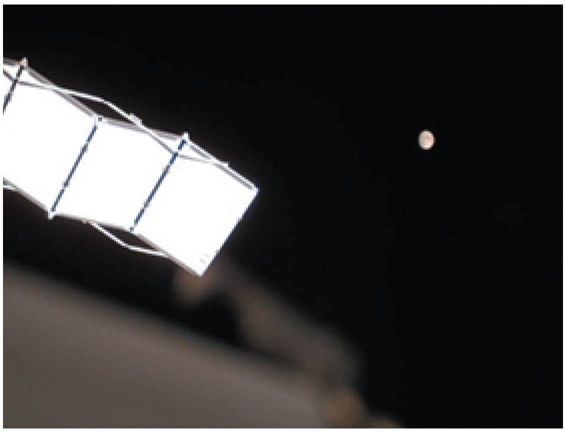
The sizes of rockets



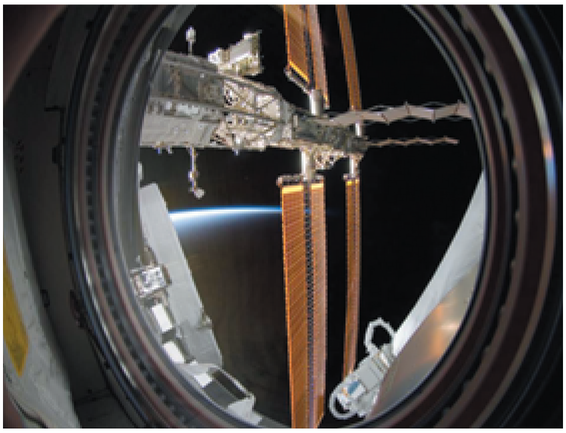
The distance from the school to space



The distance from the school to the ISS and satellites



The moon from the ISS



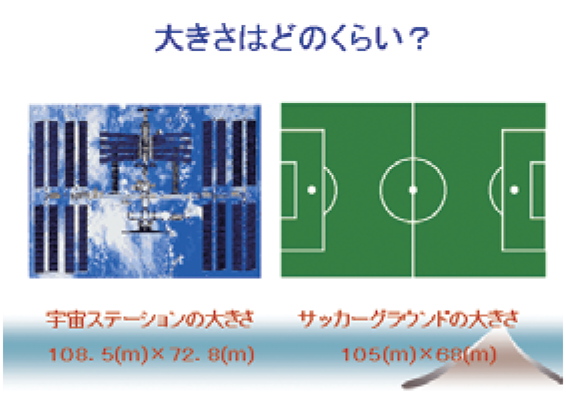
The earth from the ISS

The earth from the ISS

A Japanese astronaut is taking a photo

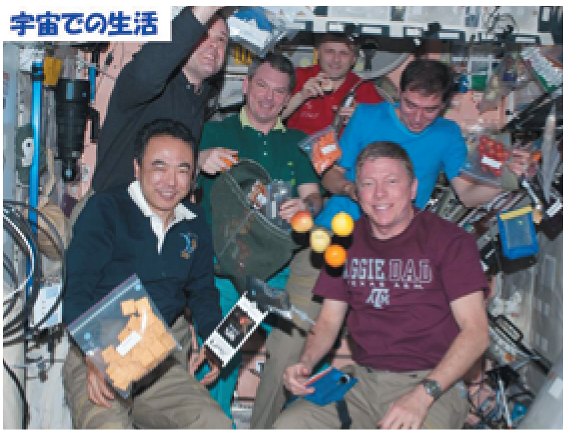
A photo of Mt. Fuji taken by an astronaut

The ISS

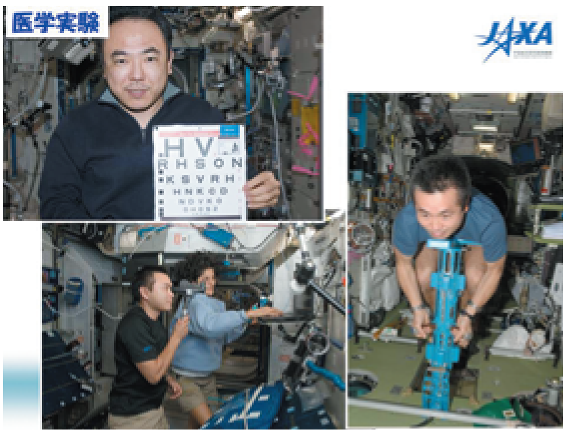


The size of the ISS

The weight of the ISS



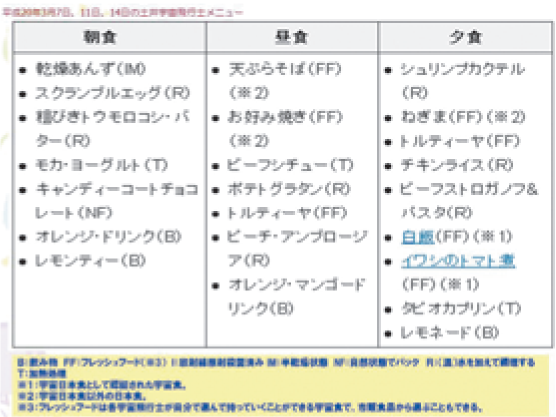
Life in space



Medical experiments

Botanical experiments

Meals



朝食	昼食	夕食
• 乾燥あんず(IM) • スクランブルエッグ(R) • 粗びきトウモロコシ・バター(R) • モカ・ヨーグルト(T) • キャンディーコートチョコレート(NF) • オレンジ・ドリンク(B) • レモンティー(B)	• 天ぷらそば(FF)(※2) • お好み焼き(FF)(※2) • ビーフシチュー(T) • ポテトグラタン(R) • トルティーヤ(FF) • ピーチ・アンブロージア(R) • オレンジ・マンゴードリンク(B)	• シュリンプカクテル(R) • ねぎま(FF)(※2) • トルティーヤ(FF) • チキンライス(R) • ビーフストロガノフ&パスタ(R) • 白飯(FF)(※1) • イワシのトマト煮(FF)(※1) • タピオカプリン(T) • レモネード(B)

※1:宇宙日本食として認証された宇宙食。
※2:宇宙日本食以外の日本食。
※3:フレッシュフードは各宇宙飛行士が自分で選んで持っていくことができる宇宙食で、市販食品から選ぶこともできる。

A food menu (e.g., *soba, okonomiyaki, yakitori*)

Leisure

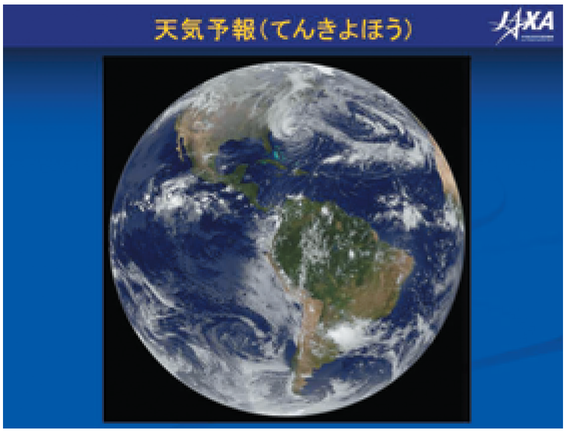
The price and weight of a spacesuit
($10M, 265 lbs.)

The purposes of space exploration
(Unravel the mysteries of space)

Indians' image of space 5,000 years ago

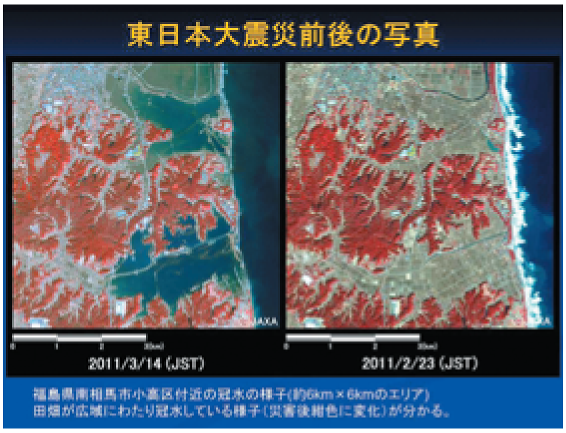
The sizes of planets (e.g., if you compare the size of the earth to a coin like a quarter, Jupiter can be compared to a basketball.)

The purposes of space exploration
(Space technologies in daily life)

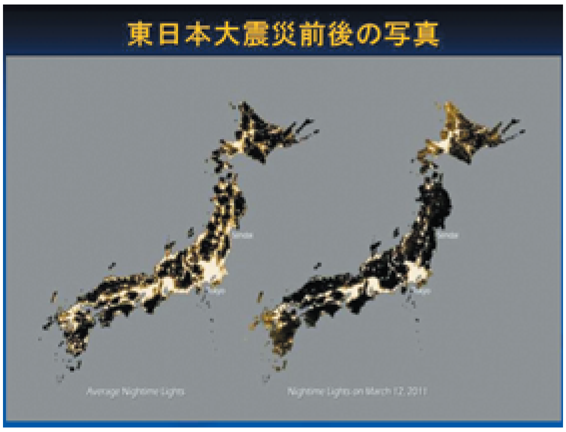


Weather forecasts

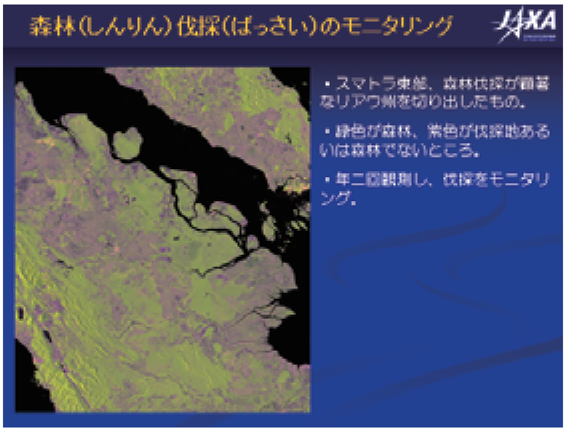
Hurricane Sandy



Before (right) and after (left) the
March 11, 2011 Earthquake and Tsunami



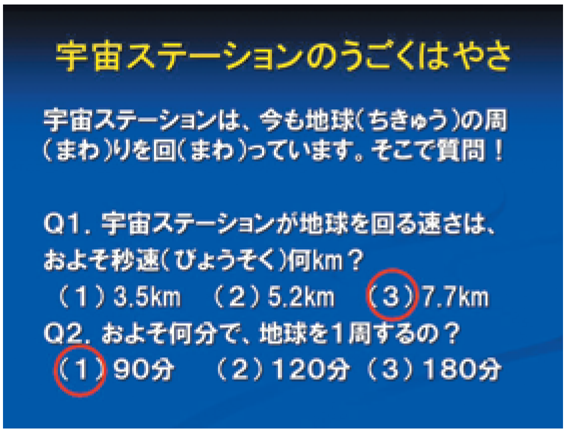
Before (left) and after (right) the March 11, 2011 Earthquake and Tsunami



The monitoring of illegal logging

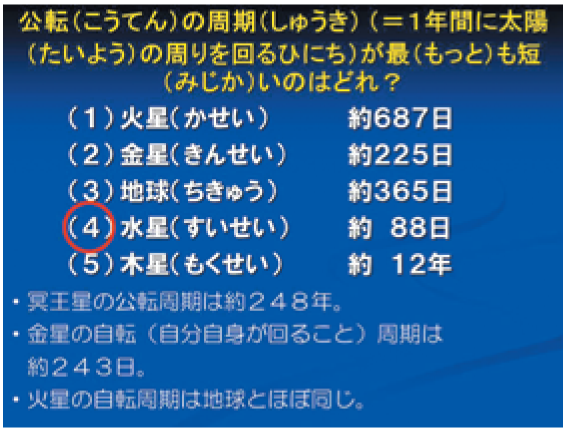
Spin-offs (e.g., GPS, CT scanning system)

Quizzes



The speed of ISS (e.g., 5 miles per second)

The speeds of objects (e.g., the earth goes around the sun by 19 miles per second)



The revolution periods of the planets of the solar system (e.g., Mars, 687 days; Venus, 225 days; Mercury, 88 days; Jupiter, 12 years; Pluto, 248 years)

The night of the earth

9.3. Questionnaires and Discussion Guides

As examples, the following are:

(a) Questionnaires used at schools in Japan (after the lecture) and in the U.S. (before and after the lecture), and

(b) Discussion guides for focus group discussions at a school in the U.S. (after the lecture).

(a) A questionnaire at a school in Japan after the lecture

質問 (Questions)	**答え (Answers)**
Q1：理科は好きですか? (Do you like science?) （１つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q2：理科は得意ですか? (Are you good at science?) （１つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-1：理科は、あなたにとって役に立つ／必要だと思いますか? (Is science useful, helpful /necessary, important for you?) （１つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-2：**(Q3-1 で「3. そう思う」または「4. 強くそう思う」と答えた人のみお答え下さい。）なぜ、「3. そう思う」または「4. 強くそう思う」と思ったのですか? そう思った理由をお答え下さい。（当てはまるものを全て選ぶ）** **(ONLY IF YOU CHOSE No.3「そう思う」(“Agree a little”) or No. 4「強くそう思う」(“Agree a lot”),)** please choose a reason(s) why you think science is useful, helpful/	1. 日々の暮らしに役に立つから (1. To help me in my daily life) 2. 好奇心を育てる／養うのに役に立つから (2. To develop my intellectual curiosity) 3. 他の教科を勉強するのに必要だから (3. To learn other school subjects) 4. 行きたい学校に入るのに必要だから (4. To get into the school of my choice) 5. 自分の希望する仕事に就くのに必要だから (5. To get the job I want) 6. その他（具体的に書いて下さい：　）

necessary, important. (**<u>Choose all the answers that describe your opinions</u>**)	(6. Others (specifically:))
Q4：正しいのはどちらですか? (Which is correct?) （1つだけ選ぶ） (Choose one)	1.　地球は太陽のまわりを回っている (1. The earth goes around the sun.) 2.　太陽は地球のまわりを回っている (2. The sun goes around the earth.)
Q5：日が沈む方角はどちらですか? (Where does the sun go down?) （1つだけ選ぶ） (Choose one)	1. 南(1. South)　2. 東(2. East)　3. 西(3. West) 4. わからない (4. I don't know)
Q6：月の形が毎日変わるのはどうしてですか? (Why does the shape of the moon change every day?) （1つだけ選ぶ） (Choose one)	1.　いろいろな形の月があるから (1. There are many different-shaped moons.) 2.　月が地球のかげに入るから (2. The moon passes into the earth's shadow.) 3.　地球から見て、太陽と月の位置関係が変わるから (3. The positional relation between the sun and the moon changes as seen from the earth.) 4.　わからない (4. I don't know.)
Q7：今日の講演を聞く前は、理科に興味はありましたか? (Before today's lecture, were you interested in science?) （1つだけ選ぶ） (Choose one)	1.　まったくない (1. No) 2.　ややある (2. Yes, but a little) 3.　ある (3. Yes) 4.　すごくある (4. Yes, a lot)
Q8-1：今日の講演を聞いて、宇宙により興味を持つようになりましたか? (Do you think today's lecture might increase your interest in space?) （1つだけ選ぶ） (Choose one)	1.　ならなかった (1. No) 2.　ややなった (2. Yes, but a little) 3.　なった (3. Yes) 4.　とてもなった (4. Yes, a lot)
Q8-2：<u>(Q8-1で「2.　ややなった」、「3.　なった」または「4.　とてもなった」と答えた人のみお答え下さい。)　**宇宙の中のどの分野が、宇宙により興味を持つきっかけになりましたか?　（当**</u>	1.　ロケット (1. Rocket) 2.　人工衛星 (2. Satellite) 3.　宇宙飛行士、国際宇宙ステーション

てはまるものを全て選ぶ） **(ONLY IF YOU CHOSE「２．ややなった」（“2. Yes, a little bit”), 「３．なった」（“3. Yes”) or「４．とてもなった」(“4. Yes, a lot”),)** which aerospace program(s) might increase your interest in space? **(Choose all the answers that describe your opinions)**	(3. Astronaut/The International Space Station) 4. 星、天体 (4. Stars, planets) 5. 日々の生活で使われている宇宙の技術 (5. Space technologies in daily life) 6. その他（具体的に書いて下さい：　　　　　　） (6. Others (specifically:　　　　　　))
Q9-1：今日の講演を聞いて、他の教科により興味を持つようになりましたか? (Do you think today's lecture might increase your interest in other subject(s)?) （１つだけ選ぶ） (Choose one)	1. ならなかった (1. No) 2. ややなった (2. Yes, but a little) 3. なった (3. Yes) 4. とてもなった (4. Yes, a lot)
Q9-2：(Q9-1 で 「2. ややなった」、「3. なった」または「4. とてもなった」と答えた人のみお答え下さい。） どの教科により興味を持つようになりましたか?（当てはまるものを全て選ぶ） **(ONLY IF YOU CHOSE「２．ややなった」（“2. Yes, a little bit”), 「３．なった」（“3. Yes”) or「４．とてもなった」(“4. Yes, a lot”),)** in which subject(s) have you become more interested? **(Choose all the answers that describe your opinions)**	1. 国語 (1. Japanese language) 2. 社会 (2. History) 3. 算数／数学 (3. Arithmetic/Mathematics) 4. 理科 (4. Science) 5. 体育 (5. Sports) 6. 音楽 (6. Music) 7. その他（具体的に書いて下さい：　　　　　　） (7. Others (specifically:　　　　　　))
Q10-1：宇宙に関する情報をどこで得ていますか? （当てはまるものを全て選ぶ） (Where do you get information on	1. 学校 (1. School) 2. テレビ (2. TV) 3. 新聞 (3. Newspaper) 4. ラジオ (4. Radio) 5. 本、雑誌 (5. Book, magazine)

space?) **<u>(Choose all the answers that apply to you)</u>**	6. 科学館、博物館 (6. Museum) 7. インターネット (7. The Internet) 8. 家族 (8. Family member) 9. その他（具体的に書いて下さい：　　　　） (9. Others (specifically:　　　　))
Q10-2：<u>(Q10-1で「7. インターネット」と答えた人のみお答え下さい。）今まで、宇宙に関する情報をソーシャル・メディア（例、フェイスブック、ツイッター、ユーチューブ、ブログ）から得たことはありますか?</u>（1つだけ選ぶ） **<u>(ONLY IF YOU CHOSE「7. インターネット」（“7. The Internet”),)</u>** have you got information on space through social media (e.g., Facebook, Twitter, YouTube, blog) before? (Choose one)	1. ある (1. Yes) 2. ない (2. No)
Q10-3：<u>(Q10-2で「1. ある」と答えた人のみお答え下さい。）　どちらのサイトから宇宙に関する情報を得たことがありますか?（当てはまるものを全て選ぶ）</u> **<u>(ONLY IF YOU CHOSE「1. ある」(“1. Yes”),)</u>** from which site(s) have you got? **<u>(Choose all the answers that apply to you)</u>**	1. フェイスブック（Facebook） 2. ツイッター（Twitter） 3. ユーチューブ（YouTube） 4. ブログ (Blog) 5. その他（具体的に書いて下さい：　　　　） (5. Others (specifically:　　　　))
Q11：あなたの学年は? (What is your grade?) （1つだけ選ぶ） (Choose one)	1. 小学校５年生 (1. 5th grade) 2. 小学校６年生 (2. 6th grade) 3. その他（具体的に書いて下さい：　　　　） (3. Others (specifically:　　　　))
Q12：あなたの性別は? (Please tell us if you're a boy or a girl.)	1. 男子 (1. Boy) 2. 女子 (2. Girl)

（1つだけ選ぶ） (Choose one)	
Q13：どこに住んでいますか? (Where do you live?) （1つだけ選ぶ） (Choose one)	1. ○○ (1.○○) 2. その他（具体的に書いて下さい：　　　） (2. Others (specifically:　　　))
Q14：その他、感想やご意見があれば、自由に書いて下さい。 (If you have any comments and thoughts, please write)	(具体的に書いて下さい(specifically)： ）

Questionnaires at a school in the U.S.

Before the lecture

質問 (Questions)	答え (Answers)
Q1：理科は好きですか? (Do you like science?) （1つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q2：理科は得意ですか? (Are you good at science?) （1つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-1：理科は、あなたにとって役に立つ／必要だと思いますか? (Is science useful, helpful /necessary, important for you?) （1つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-2：**(Q3-1で「3. そう思う」または「4. 強くそう思う」と答えた人のみお答え下さい。）なぜ、「3. そう思う」または「4. 強くそう思う」と思ったのですか? そう思った理由をお答え下さ**	1. 日々の暮らしに役に立つから (1. To help me in my daily life) 2. 好奇心を育てる／養うのに役に立つから (2. To develop my intellectual curiosity) 3. 他の教科を勉強するのに必要だから

い。（当てはまるものを全て選ぶ） **(ONLY IF YOU CHOSE No.3「そう思う」 ("Agree a little") or No. 4 「強くそう思う」 ("Agree a lot"),)** please choose a reason(s) why you think science is useful, helpful/ necessary, important. **(Choose all the answers that describe your opinions)**	(3. To learn other school subjects) 4. 行きたい学校に入るのに必要だから (4. To get into the school of my choice) 5. 自分の希望する仕事に就くのに必要だから (5. To get the job I want) 6. その他（具体的に書いて下さい： ） (6. Others (specifically:))
Q4：正しいのはどちらですか? (Which is correct?) （1つだけ選ぶ） (Choose one)	1. 地球は太陽のまわりを回っている (1. The earth goes around the sun.) 2. 太陽は地球のまわりを回っている (2. The sun goes around the earth.)
Q5：日が沈む方角はどちらですか? (Where does the sun go down?) （1つだけ選ぶ） (Choose one)	1. 南 (1. South) 2. 東 (2. East) 3. 西(3. West) 4. わからない (4. I don't know)
Q6：月の形が毎日変わるのはどうしてですか? (Why does the shape of the moon change every day?) （1つだけ選ぶ） (Choose one)	1. いろいろな形の月があるから (1. There are many different-shaped moons.) 2. 月が地球のかげに入るから (2. The moon passes into the earth's shadow.) 3. 地球から見て、太陽と月の位置関係が変わるから (3. The positional relation between the sun and the moon changes as seen from the earth.) 4. わからない (4. I don't know.)
Q7：理科に興味はありますか? (Are you interested in science?) （1つだけ選ぶ） (Choose one)	1. まったくない (1. No) 2. ややある (2. Yes, but a little) 3. ある (3. Yes) 4. すごくある (4. Yes, a lot)
Q8-1：宇宙に関する情報をどこで得ていますか? **（当てはまるものを全て選ぶ）** (Where do you get information on space?) **(Choose all the answers**	1. 学校 (1. School) 2. テレビ (2. TV) 3. 新聞 (3. Newspaper) 4. ラジオ (4. Radio) 5. 本、雑誌 (5. Book, magazine) 6. 科学館、博物館 (6. Museum)

that apply to you)	7. インターネット (7. The Internet) 8. 家族 (8. Family member) 9. その他（具体的に書いて下さい：　　　　） (9. Others (specifically:　　　　))
Q8-2：(Q8-1 で 「7. インターネット」と答えた人のみお答え下さい。）今まで、宇宙に関する情報をソーシャル・メディア（例、フェイスブック、ツイッター、ユーチューブ、ブログ）から得たことはありますか?（1 つだけ選ぶ） **(ONLY IF YOU CHOSE「７．インターネット」 (“7. The Internet”),)** have you got information on space through social media (e.g., Facebook, Twitter, YouTube, blog) before? (Choose one)	1. ある (1. Yes) 2. ない (2. No)
Q8-3：(Q8-2 で 「1. ある」と答えた人のみお答え下さい。） どちらのサイトから宇宙に関する情報を得たことがありますか?（当てはまるものを全て選ぶ） **(ONLY IF YOU CHOSE「１. ある」(“1. Yes”),)** from which site(s) have you got? **(Choose all the answers that apply to you)**	1. フェイスブック（Facebook） 2. ツイッター（Twitter） 3. ユーチューブ（YouTube） 4. ブログ (Blog) 5. その他（具体的に書いて下さい：　　　　） (5. Others (specifically:　　　　))
Q9：あなたの学年は? (What is your grade?) （1 つだけ選ぶ） (Choose one)	1. 小学校３年生 (1. 3rd grade) 2. 小学校４年生 (2. 4th grade) 3. その他（具体的に書いて下さい：　　　　） (3. Others (specifically:　　　　))
Q10：あなたの性別は? (Please tell us if you're a boy or a girl.) （1 つだけ選ぶ） (Choose one)	1. 男子 (1. Boy) 2. 女子 (2. Girl)

Q11： どこに住んでいますか? (Where do you live?) （1つだけ選ぶ） (Choose one)	1. 〇〇 (1.〇〇) 2. その他 （具体的に書いて下さい： ） (2. Others (specifically:))
Q12： その他、感想やご意見があれば、自由に書いて下さい。 (If you have any comments and thoughts, please write)	(具体的に書いて下さい(specifically)：)

After the lecture

質問 (Questions)	答え (Answers)
Q1： 理科は好きですか? (Do you like science?) （1つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q2： 理科は得意ですか? (Are you good at science?) （1つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-1： 理科は、あなたにとって役に立つ／必要だと思いますか? (Is science useful, helpful /necessary, important for you?) （１つだけ選ぶ） (Choose one)	1. まったくそう思わない (1. Disagree a lot) 2. そう思わない (2. Disagree a little) 3. そう思う (3. Agree a little) 4. 強くそう思う (4. Agree a lot)
Q3-2： (Q3-1 で 「3. そう思う」または「4. 強くそう思う」と答えた人のみお答え下さい。）なぜ、「3. そう思う」または「4. 強くそう思う」と思ったのですか? そう思った理由をお答え下さい。（当てはまるものを全て選ぶ） **(ONLY IF YOU CHOSE No.3「そう思う」("Agree a little") or No. 4 「強く**	1. 日々の暮らしに役に立つから (1. To help me in my daily life) 2. 好奇心を育てる／養うのに役に立つから (2. To develop my intellectual curiosity) 3. 他の教科を勉強するのに必要だから (3. To learn other school subjects) 4. 行きたい学校に入るのに必要だから (4. To get into the school of my choice) 5. 自分の希望する仕事に就くのに必要だから

そう思う」（“Agree a lot”),) please choose a reason(s) why you think science is useful, helpful/ necessary, important. **(Choose all the answers that describe your opinions)**	(5. To get the job I want) 6. その他（具体的に書いて下さい： ） (6. Others (specifically:))
Q4：理科に興味はありますか? (Are you interested in science?) （１つだけ選ぶ） (Choose one)	1. まったくない (1. No) 2. ややある (2. Yes, but a little) 3. ある (3. Yes) 4. すごくある (4. Yes, a lot)
Q5-1：今日の講演を聞いて、宇宙により興味を持つようになりましたか? (Do you think today’s lecture might increase your interest in space?) （１つだけ選ぶ） (Choose one)	1. ならなかった (1. No) 2. ややなった (2. Yes, but a little) 3. なった (3. Yes) 4. とてもなった (4. Yes, a lot)
Q5-2：**(Q5-1 で「2. ややなった」、「3. なった」または「4. とてもなった」と答えた人のみお答え下さい。）宇宙の中のどの分野が、宇宙により興味を持つきっかけになりましたか?（当てはまるものを全て選ぶ）** **(ONLY IF YOU CHOSE「２．ややなった」（“2. Yes, a little bit”),「３．なった」（“3. Yes”) or「４．とてもなった」（“4. Yes, a lot”),)** which aerospace program(s) might increase your interest in space? **(Choose all the answers that describe your opinions)**	1. ロケット (1. Rocket) 2. 人工衛星 (2. Satellite) 3. 宇宙飛行士、国際宇宙ステーション (3. Astronaut/The International Space Station) 4. 星、天体 (4. Stars, planets) 5. 日々の生活で使われている宇宙の技術 (5. Space technologies in daily life) 6. その他（具体的に書いて下さい： ） (6. Others (specifically:))
Q6-1：今日の講演を聞いて、他の教科により興味を持つようになりましたか? (Do you think today’s lecture might increase your interest in other subject(s)?)	1. ならなかった (1. No) 2. ややなった (2. Yes, but a little) 3. なった (3. Yes) 4. とてもなった (4. Yes, a lot)

（１つだけ選ぶ） (Choose one)	
Q6-2：**(Q6-1 で「2. ややなった」、「3. なった」または「4. とてもなった」と答えた人のみお答え下さい。） どの教科により興味を持つようになりましたか?（当てはまるものを全て選ぶ）** **(ONLY IF YOU CHOSE「２．ややなった」（"2. Yes, a little bit"),「３．なった」（"3. Yes") or「４．とてもなった」("4. Yes, a lot"),)** in which subject(s) have you become more interested? **(Choose all the answers that describe your opinions)**	1. 国語 (1. Japanese language) 2. 社会 (2. History) 3. 算数／数学 (3. Arithmetic/Mathematics) 4. 理科 (4. Science) 5. 体育 (5. Sports) 6. 音楽 (6. Music) 7. その他（具体的に書いて下さい： ） (7. Others (specifically:))
Q7：あなたの学年は? (What is your grade?) （１つだけ選ぶ） (Choose one)	1. 小学校３年生 (1. 3rd grade) 2. 小学校４年生 (2. 4th grade) 3. その他（具体的に書いて下さい： ） (3. Others (specifically:))
Q8：あなたの性別は? (Please tell us if you're a boy or a girl.) （１つだけ選ぶ） (Choose one)	1. 男子 (1. Boy) 2. 女子 (2. Girl)
Q9：どこに住んでいますか? (Where do you live?) （１つだけ選ぶ） (Choose one)	1. ○○ (1.○○) 2. その他（具体的に書いて下さい： ） (2. Others (specifically:))
Q10：その他、感想やご意見があれば、自由に書いて下さい（【例１】講演を聞いてあなたの理科に対する考えは変わりましたか？それは何故ですか？【例２】あなたが今日学んだもっとも重要なことはなんですか？）。	（具体的に書いて下さい(specifically)：

(If you have any comments and thoughts, please write (e.g., do you think today's lecture will change the way you think about science? Tell us why or why not; what was the most important thing you learned today?).)	)

(b) Discussion guides

For students

Discussion Guide (For Students)

1. Intro (3 min)

A. About me

B. Explain the purpose and ground rules (e.g., ethics).

・This interview is for research on your interest in science, and will not be used other than the research purpose.

・If you do take this survey, we do not ask your name and nobody will know that you were in this survey. Your privacy will be guaranteed.

・This interview is voluntary. You do not have to be in this survey if you do not want to be. If you decide to stop after you begin, that's okay too.
(GIVE THEM A SENSE THAT THEY HAVE A LOT TO CONTRIBUTE.)

C. About students (ONLY FIRST NAME, NO LAST NAME)

D. Introductory questions to break the ice

・What's your favorite thing(s) in and out of school?

・Guest lecture(s) before?

・What do you think about today's lecture? Interesting? If yes, why? If no, why not?

・Do you like space? If yes, why? If no, why not?

2. Body (23 min. From broad to narrow questions)

A. Student attitudes and opinions about science

・Do you like science? If yes, why? What experience has made you like it? If no, why not? (BE CAREFUL ABOUT MY TONE. DO NOT ACCUSE.)

・Are you interested in science? (And ask the same questions as above.)

・Are you good at science? (And ask the same questions as above.)

B. Their changes in interest in science with age (FOR 8th GRADERS ONLY)

・Has your interest in science changed with age? If yes, why? What has made you decrease/lose your interest?

C. Their changes in interest in science after the lecture

・Have you become (more) interested in science? If yes, why? If no, why not?

・Have you become (more) interested in other subject(s)? If yes, why? In what subject(s), and why? If no, why not?

- Do you think space programs increase your interest in science? If yes, why? If no, why not?
- Can you name a (practical) space science discovery(ies) that impact(s) your life?

D. Information sources for space

- Do you get information on space? How? How often? Where? (e.g., at school)
- What information on space is most memorable? Why?
- Have you heard of social media? Have you got information on space through it? If yes, from which site(s) have you got information on space and why? If no, why not?
- Have you got information on space from a teacher(s)/parent(s)? If yes, what information?

E. Their ideas, opinions about solutions for *rika banare*

- What might make you more interested in science? (yourself, school, teacher, the media, home, etc.)
  (ENCOURAGE THEIR CREATIVE THOUGHTS.)

3. Summary (3 min)

A. Ask them anything that we should have talked about but did not to follow up the interview.
B. Ask their opinions and thoughts about the focus group discussion, so that I can improve for future research.

4. Conclusion (1 min)

For Teachers

Discussion Guide (For Teachers)

1. Intro (3 min)

A. About me
B. Explain the purpose and ground rules (e.g., ethics).
- This interview is for research on students' interest in science, and will not be used other than the research purpose.
- Explain why I need interviews w/ math teachers, not w/ science teachers.
- If you do take this survey, we do not ask your name and nobody will know that you were in this survey. Your privacy will be guaranteed.
- This interview is voluntary. You do not have to be in this survey if you do not want to be. If you decide to stop after you begin, that's okay too.

(GIVE THEM A SENSE THAT THEY HAVE A LOT TO CONTRIBUTE.)

C. About teachers (ONLY FIRST NAME, NO LAST NAME)
- When did you come to the school? Please tell me about your career. What do you teach?

D. Introductory questions to break the ice
- What do you think about today's lecture? Interesting? If yes, why? If no, why not?
- Do you like space? If yes, why? If no, why not?

2. Body (23 min. From broad to narrow questions)

A. Students' attitudes about math/science
- In general, do you think they like math/science? If yes, why? If no, why not?
- In general, do you think they are interested in math/science? (And ask the same questions as above.)
- In general, do you think they feel good at math/science? (And ask the same questions as above.)
- Is there anything you take special care of in education?
- Any differences from Japanese students in Japan?

B. Students' changes in interest in math/science
- Have you seen their changes in interest in math/science from the past? If yes, why? If no, why not?
- Do you think their interest in math/science has changed with age? If yes, why? What has made them decrease/lose their interest?

・Is there anything you take special care of in education?
・Any differences from Japanese students in Japan?

C. The new school curriculum
・Any impact(s)? (e.g., systematic teaching, achievement level, achievement gap)
・Any problem(s) to introduce the curriculum?

D. Students' changes in interest in math/science after the lecture
・Do you think they have become (more) interested in math/science? If yes, why? If no, why not?
・Do you think space programs increase their interest in math/science? If yes, why? If no, why not?
・What information on space do you think is most memorable for them? Why?
・Do you think they have become (more) interested in other subjects? If yes, why? In what subjects, and why? If no, why not?

E. Information sources for space
・What do you think about their use of the Internet, including social media? Which site(s) do they use? Why? How often? Where?
・Do you think they get information on math/science from the Internet, including social media? Which site(s) do they use? Why? How often? Where?
・Would you recommend that they get information on math/science on the Internet, including social media?

F. Their ideas, opinions about solutions for *rika banare*
・What might make them more interested in math/science? (themselves, school, teacher, the media, home, etc.)
(ENCOURAGE THEIR CREATIVE THOUGHTS.)

3. Summary (3 min)

A. Ask them anything that we should have talked about but did not to follow up the interview.
B. Ask their opinions and thoughts about the focus group discussion, so that I can improve for future research.

4. Conclusion (1 min)

Japan Aerospace
Exploration Agency

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