Expanding access: The effectiveness of online science events in attracting a wider audience

Chisato Ikuta
Institution Japan Aerospace Exploration Agency, The Graduate University for Advanced Studies, SOKENDAI
ikuta.chisato@jaxa.jp

Keywords
COVID-19, Lecture, Public Outreach, Survey, Online Activities, Online Engagement

Amid the COVID-19 pandemic, researchers and science communicators experienced a rapid and unprecedented transformation from in-person to online science communication activities. One of the advantages of online activities is now considered to be the ability to include a broader range of people in scientific activities, including women and ethnic minorities. In this report, we quantify the impact of the in-person or online communication mode on the registrants' and attendees' demographics and discuss the potential of engaging a broader range of people at online science events. Hosting online public lectures and analysing survey results for the registrations and attendees, we find the age distribution of the attendees showcases a much higher fraction of teens and younger participants compared with an in-person case. The result also demonstrates that the fraction of female participants was higher in the online lectures. Our survey results suggest that an online public lecture allows us to reach more young people in their teens and twenties, as well as those underrepresented in STEM, such as women. We also found that providing the online recorded video was essential to sharing scientific stories with a broader audience.

Introduction

In 2020, the COVID-19 pandemic and the subsequent infection prevention and control actions forced the suspension of in-person public programmes in Japan. The pandemic caused a dramatic shift to introduce online events to keep engaging with the public. During the pandemic, the number of people using online meeting applications suddenly increased (e.g., *Ministry of Internal Affairs of Japan, 2021*). Additionally, environmental concerns associated with in-person conferences, which are travel-intensive, became more pronounced. Researchers flying to attend conferences contribute significantly to greenhouse gas emissions (see, e.g., *Moss et al., 2021,* and references therein). Online events have demonstrated the potential to reduce access barriers and shrink carbon footprints (see e.g., *The Editorial Board, 2022*, and references therein). Inevitably, studies were conducted on attempts at online scientific communication and education (e.g., *Christoph et al., 2021; Dew et al., 2021; Penteado et al., 2021; Roche et al., 2021; Radin & Light, 2022*). Previous studies reported some areas where virtual interaction is considered inferior to face-to-face interaction. These areas include suppressing creative idea generation (e.g., *Brucks & Levav, 2021*) and reduced networking opportunities (e.g., *Moss et al., 2021; Skiles et al., 2021*). On the other hand, many successful cases of online scientific activities have also been reported (e.g., *Massey, 2021*). It is often mentioned that online scientific activities allow the inclusion of those who did not join in in-person activities (e.g., *Sarabipour et al., 2021; van der Wal, 2022; Köhler et al., 2022; Wu et al., 2022*). However, previous studies did not provide sufficient quantitative analysis.

In this study, we report survey results for registrations and attendees of online public lectures, hereafter "webinars". By comparing these webinars to an in-person lecture, we found that online public lectures may improve inclusion for women and young people in their teens and twenties. We also found that online outreach activities provide convenient opportunities for people in regions of Japan where science events are less frequent and accessible.

Unless otherwise stated, the level of statistical significance is defined as a p-value of less than 0.05 in this report.

Outline of the webinars

Table 1 summarises the content covered in and attendance of webinars hosted in 2021 and 2022. All speakers were professional astrophysicists working at universities or research institutes in Japan. Each webinar was held in Zoom and consisted of two talks: a 20-minute presentation and a 15-minute Q&A session conducted in Japanese. The webinars were advertised only online via X (formerly Twitter), websites and mailing lists.

In 2021, we prepared two registration methods: a web form and a Zoom form. The link to the web form was posted on the websites about one month before the webinar, and the applicants were provided with a link to connect about one week before each webinar. The other was an application directly through Zoom that was available about one week before the first webinar on the websites. In this case, the applicant received the connection link immediately after registration.

At the beginning of each webinar, a facilitator encouraged the attendees to submit their comments and questions during speakers' presentations and the Q&A sessions in Zoom's chat function. As a result, we received more than 70 questions during each webinar. More than 90% of them were sent as text messages using the Q&A function of the Zoom webinar. Asking questions and sharing comments by text

Date and start time	Theme	Number of accesses	View count on YouTube
Sunday, 7th Nov. 2021 14:00	Black holes	169	870 K
Sunday, 14th Nov. 2021 14:00	Supernovae	217	160 K
Sunday, 21st Nov. 2021 14:00	Galaxy Clusters	167	34 K
Saturday, 26th Nov. 2022 19:00	Black holes (Introduction and theoretical perspective)	128	3.7 K
Saturday, 3rd Dec. 2022 19:00	Black holes (Supermassive black holes)	112	7.1 K
Saturday, 17th Dec. 2022 19:00	Black holes (End of massive stars)	140	–

Table 1: *Outline of the webinars. Column 1 indicates the date and start time of the webinars. Column 2 presents the webinar topic. Column 3 shows the net number of accesses, excluding duplicates. Note that this number represents connections rather than individual attendees, as a single connection can encompass multiple attendees. Column 4 showcases the number of views for recordings uploaded to YouTube as of 20 May 2024. Notably, the webinar recording held on 17 November 2022, has yet to be posted due to technical issues.*

enabled participants to communicate with the speakers and each other. Other presenters or organisers responded to questions posted in the chat during the presentations, ensuring that as many inquiries were addressed as possible.

We conducted surveys before and after each webinar (hereafter referred to as the pre-survey and post-survey, respectively). The questions aimed to improve subsequent webinars and future outreach events. Respondents were informed before the pre-survey and post-survey about the aims of the surveys and that the data might eventually be published. The authors ensured the data were collected anonymously and individuals could not be identified.

All individuals who wished to attend the webinars were required to complete the pre-surveys. We collected email addresses, which were used to send the connection links for the webinars, making the provision of an email address mandatory. The persons wishing to register for the webinars could select "would rather not answer" for other questions if they did not wish to respond. The pre-surveys included demographic questions such as age, gender, and residential location. For gender, we offered four options: "female", "male", "other", and "would rather not say". A Zoom webinar administrator can access attendee reports that provide data on whether registrants attended or not. Since the pre-survey response data is linked to the attendee report data via the registrants' emails, we used compiled data files that included both the attendee reports and the pre-survey data.

Because online events enable multiple people to participate under a single login, the net number of accesses listed in Table 1 represents a minimum number of attendees. For this reason, we asked those who filled out the survey to provide the primary audience demographic information.

Participation in the post-surveys was entirely voluntary. The post-surveys were conducted using the Zoom function, where a post-survey form automatically appeared in the participant's web browser either at the end of the webinar or when the participant left. The facilitator asked the attendees to share their opinions through the post-survey. Additionally, the webinar organiser sent attendees a link to the post-survey form after each webinar. Although the post-survey form remained open for at least one week, over 92% of respondents completed and submitted it within one hour of each webinar.

Results of the 2021 webinars

Figure 1 shows the age distribution of the registrants and attendees. Some registrants and attendees indicated they were younger than nine years old; in these cases, we assume their parents or guardians answered the pre-survey questions. About 4% of the registrants did not provide answers about their age or gender, so these data are excluded from analyses that include age and gender variables.

Figure 2 displays the attendance rate of each age group separated by gender, while Figure 3 compares the attendance rate separated by the registration method. From Figure 2, the attendance rates of the older generation are higher than those of the younger. Figure 3 shows a much higher attendance rate of the applicants through the Zoom form.

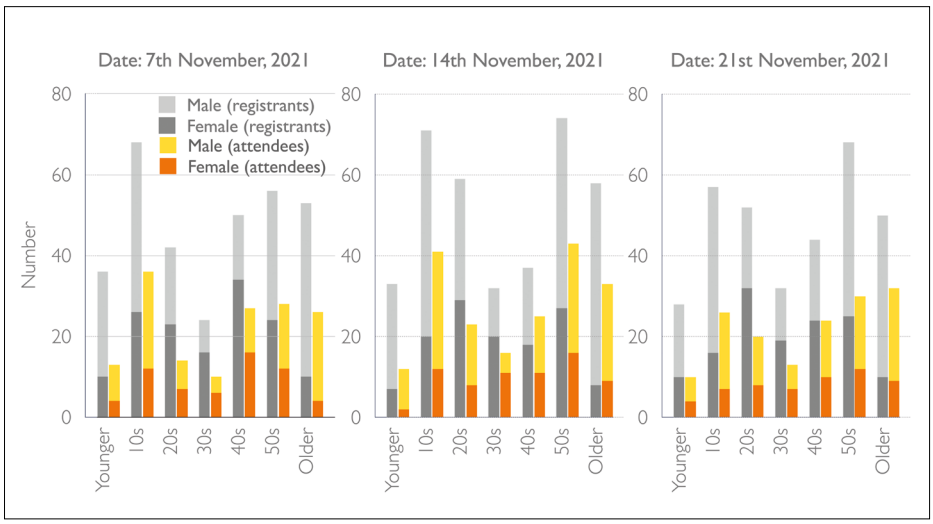

Figure 1: *Age and gender distributions of registrants (deep grey and light grey bars) and attendees (orange and yellow bars) at the webinars in 2021.*

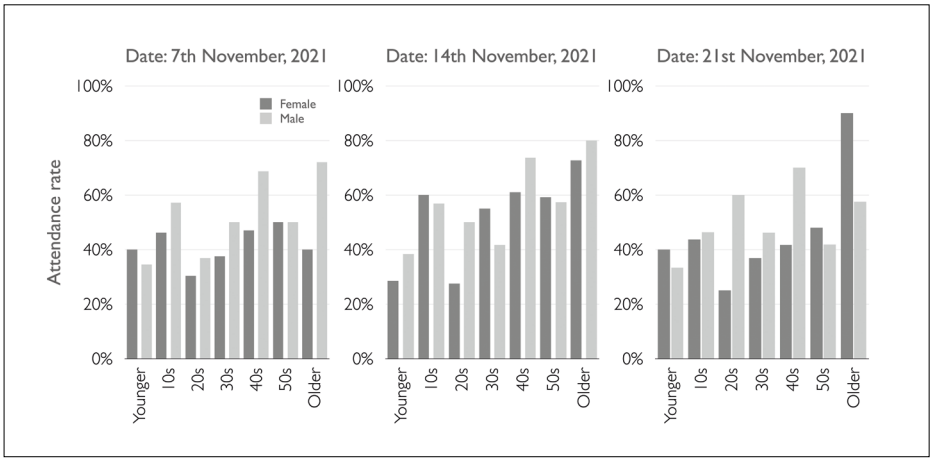

Figure 2: *Attendance rates of each age and gender group at the webinars in 2021.*

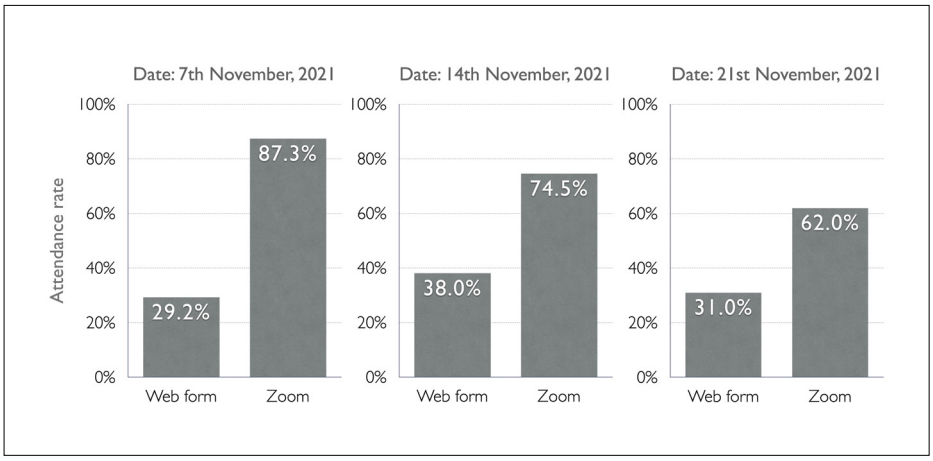

Figure 3: *Comparison of the attendance rates for different registration methods.*

We conducted a logistic regression analysis to understand how age group, gender, location, and registration method affect the attendance rate. In this analysis, the attendance rate was the target variable, and the predictor variables were age group, gender, location of residence, and registration method. The results indicated that the most important predictor variable was the registration method, with an odds ratio of 0.14 for registrations through the web form compared to the Zoom form. Notably, after the first webinar, we checked the attendance rate and subsequently sent reminders to all registrants for the succeeding webinars.

Figure 4 and Figure 5 show the post-survey results, respectively, the preference for the length of each presentation and the Q&A session. The post-survey response rate was about 60%. There was no significant difference in the response rates among the webinars. Although the 20-minute presentation during our webinars was shorter than the standard in-person presentation for the general public (at the National Astronomical Observatory of Japan or Japan Aerospace Exploration Agency, this is usually 30 to 50 minutes), more than 80% of participants answered that they liked the length. Conversely, the 15-minute Q&A session was relatively longer than those typically conducted during in-person public lectures aimed at the general public (excluding lectures specifically targeted at children) organised by our institutes. As shown in Figure 5, over 85% of the respondents indicated that the 15-minute Q&A session was appropriate length.

In the post-survey, we asked the attendees to rate each presentation on a 10-point scale according to clarity (1=least clear; 10=most clear). The distributions of the ratings were skewed towards higher values, and the level of the presentations was appropriate, as shown in Figure 6. Fewer respondents rated the webinars a 9 compared to those who rated them an 8 or 10. A similar pattern is observed in the post-surveys from 2022, as shown in Figure 11. This trend will be discussed in more detail in a subsequent sub-section. The medians for all three webinars were 8. However, the mean scores were approximately 7 for the first webinar and approximately 8 for the second and third webinars. The standard deviations of these scores were 2.44, 2.06, and 1.85, respectively. This variation in mean scores suggests that the first webinar was rated lower than the others. To determine if this variation was statistically significant, we conducted a one-way ANOVA (analysis of variance). We assumed the score distributions of the three webinars to be independent due to the variation in

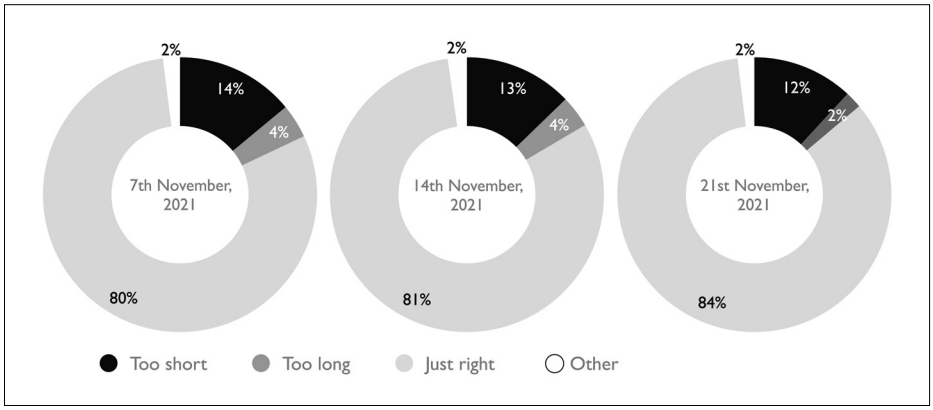

Figure 4: *Presentation length preferences for the webinars in 2021. The data are from questionnaires distributed after each webinar, where black is "Too short," dark grey is "Too long," light grey is "Just right," and white is "Other."*

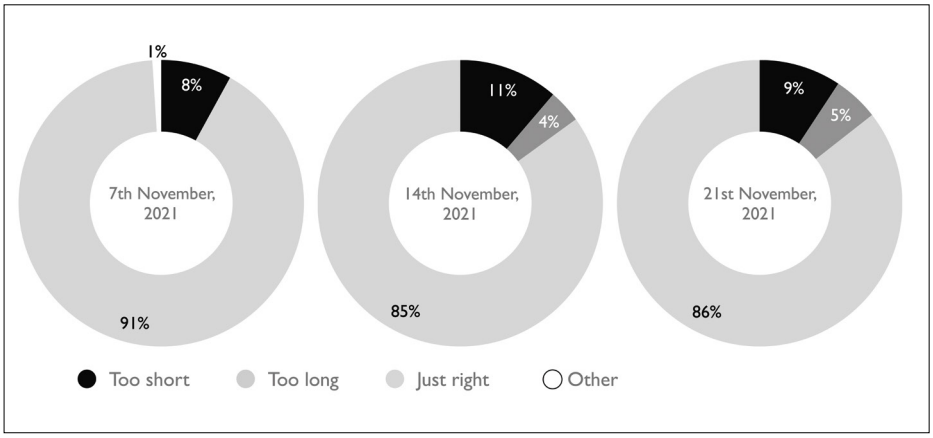

Figure 5: *Q&A session length preferences for the webinars in 2021. The data are from questionnaires distributed after each webinar, where black is "Too short," dark grey is "Too long," light grey is "Just right," and white is "Other."*

presenters across these events. The analysis revealed that the mean score for the first webinar was significantly lower than the mean scores for the other two webinars. Reading the comments from the post-survey of the first webinar, we found some feedback indicating that the presentation was too difficult or specialised. Such negative feedback was not observed for the other webinars. We speculate that the presentations were more specialised than some attendees had expected, resulting in a lower mean score for the first webinar. Interestingly, the first webinar recording garnered the highest number of views on YouTube, as shown in Table 1. This could suggest that YouTube audiences may prefer more specialised content, given the abundance of videos available online for beginners.

Results of the 2022 webinars

Table 1 also summarises the content covered in and attendance of the 2022 webinars. In 2021, we found that the attendance rate of registrations through the web form was much lower than that through the Zoom form. Therefore, we used only the Zoom form for the 2022 webinars. The structure of each webinar was the same as those in 2021, i.e., each webinar consisted of two talks: a 20-minute presentation and a 15-minute Q&A session conducted in Japanese. Because some attendees in 2021 commented that they preferred the weekend evening, and to avoid confusion between dates and starting times of events, we held all webinars on Saturday evenings in 2022 to check if the number of attendees and the attendance rate increased.

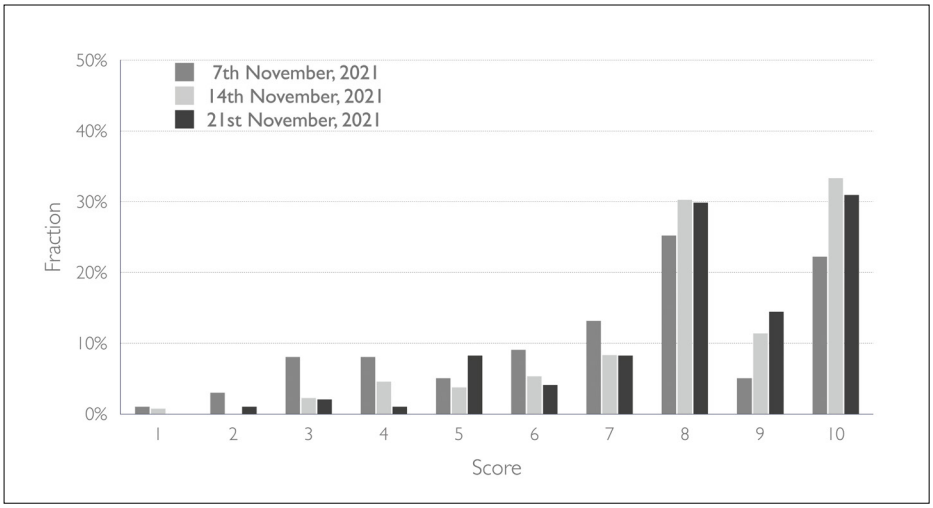

Figure 6: *Attendees were asked to rate each webinar based on how easy they were to understand. This plot shows the score distribution for each webinar. A higher score means the webinar was easier to understand.*

Figures 7 and 8 are the same as Figures 1 and 2, respectively, but for the 2022 webinars. About 20% and 3% of registrants and attendees, respectively, did not provide their age and/or gender. We excluded data without age and gender from the following analysis.

The total number of registrants for each webinar and the average attendance rate in 2022 was lower than in 2021 despite the webinars being scheduled on Saturday evenings in response to attendees' feedback. This time slot may not be optimal for attracting a larger audience.

Similar to our analysis of the 2021 data to study attendance rate, we performed a logistic regression using the same variables (excluding the registration method, which was consistent for the 2022 webinars) for the 2022 post-survey data. In contrast to the 2021 findings, we did not identify any predictor variable significantly impacting the attendance rate.

As with 2021, we asked the attendees to answer several questions about each webinar in a post-survey. The response rates were 51%, 67%, and 71% for the first, second, and third webinars, respectively, indicating an increase in post-survey participation from the first to the third webinar. Given that the theme of the 2022 webinars was consistent across all three sessions and considering that some attendees participated in multiple webinars (42 attendees attended all three webinars and 49 attended two of the three webinars), it is possible that those who attended multiple webinars responded to the post-survey only once after the last webinar they attended (either the second or the third webinar). We speculate that this contributed to the observed increase in post-survey response rates.

Figures 9 and 10 display the preference for each presentation and Q&A session lengths, respectively. They show that most attendees were satisfied with a 20-minute talk and 15-minute Q&A, which is consistent with the results from 2021. However, we noticed that the proportion of respondents who answered "Too short" in 2022 doubled compared to 2021. Several factors could explain these results. For instance, attendees of the 2022 webinars may have enjoyed the sessions more than those in 2021 and thus desired longer

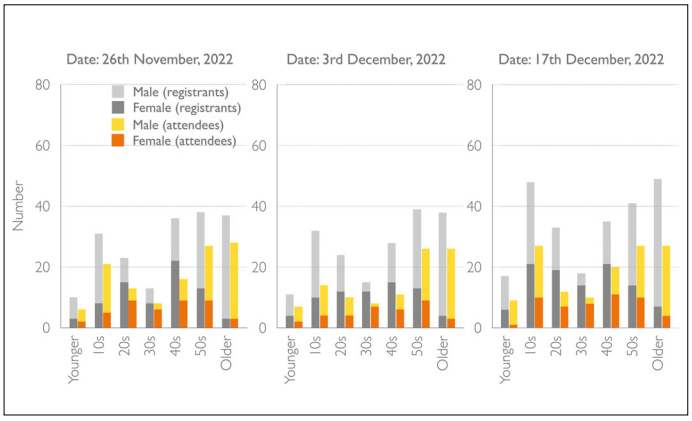

Figure 7: *Same figure as Figure 1, but for the lectures in 2022.*

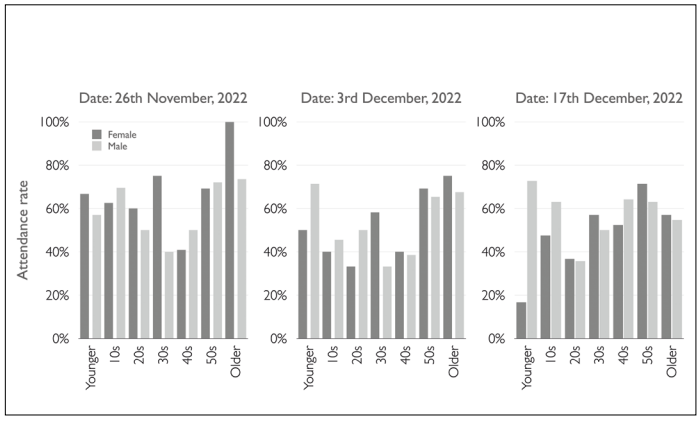

Figure 8: *Same figure as Figure 2, but for the lectures in 2022.*

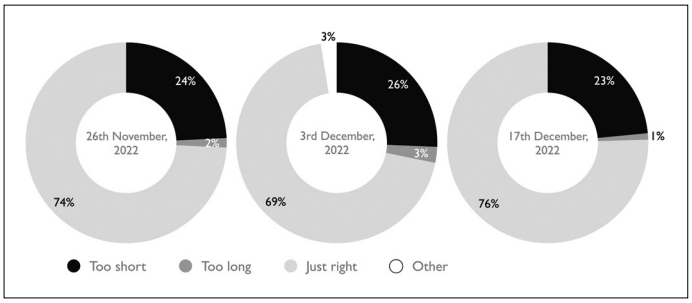

Figure 9: *Same figure as Figure 4, but for the lectures in 2022.*

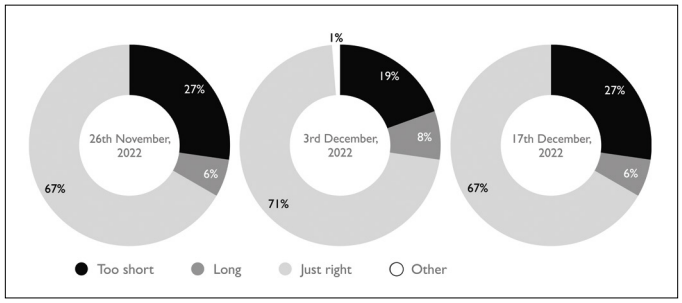

Figure 10: *Same figure as Figure 5, but for the lectures in 2022.*

presentations and Q&A sessions to ask more questions. Another possibility is that attendees might have become more accustomed to online meetings amid the pandemic, leading to a delayed onset of digital fatigue.

Figure 11 is the same as Figure 6, but for 2022. It shows that most attendees evaluated the presentations as easy to understand. The median scores were about 8 for the first and third webinars and about 9 for the second webinars. The standard deviations for the first, second, and third webinars were 1.4, 1.56, and 1.92, respectively. An ANOVA of each webinar's score suggests no significant difference between the three.

Figures 6 and 11 show score distributions with peaks at 8 and 10 and a noticeable dip at 9. Comparable datasets for public science lecture ratings or similar examples like school classes are scarce, as such data are often private. Thus, we can only speculate on the factors causing the distributions in Figures 6 and 11. Previous studies (e.g., *Krosnick & Fabrigar 1997*) suggest several psychological and behavioural factors. The respondents might avoid middle values like 9, seeing them as ambiguous, and prefer the explicit endorsement of a 10 or the cautious rating of an 8. Attendees might see 10 as perfect, 8 as very good, and find 9 lacking a distinct category or sentiment.

Comparison with an in-person public lecture

Figure 12 compares the age and gender distributions of in-person and online public lectures. The presenter provided the demographic data for the in-person lecture. The number of respondents to the

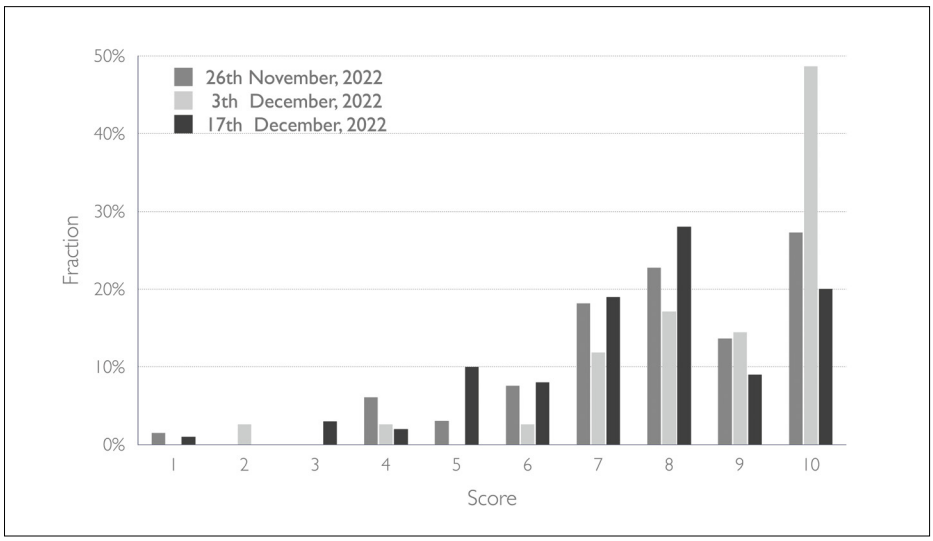

Figure 11: *Same figure as Figure 6, but for the lectures in 2022.*

in-person lecture survey was 237. This survey was conducted independently from our webinars, and as such, there was some – but not total – overlap between this survey and the post-survey used for the online study presented here. The common questions included age and gender. The survey also asked respondents about the appropriateness of the lecture length using a five-point scale, unlike our post-survey, which used a three-point scale.

As shown in Figure 12, the prominent difference between the webinars and the in-person lecture is the fraction of males older than 50, who occupied more than 50% of the attendees of the in-person lecture. Our results demonstrate that having events online provides one solution to reach young people and women.

We would like to highlight the attendees' preference regarding the length of the in-person lecture. The structure of this lecture included three 50-minute presentations followed by a 30-minute Q&A session, resulting in a total event duration of nearly three-and-a-half-hours. The survey conducted among the in-person lecture attendees asked them to rate their perception of the lecture length on a five-point scale (very short, somewhat short, just right, somewhat long, very long). Over 76% of respondents indicated that the length was "just right." The length is

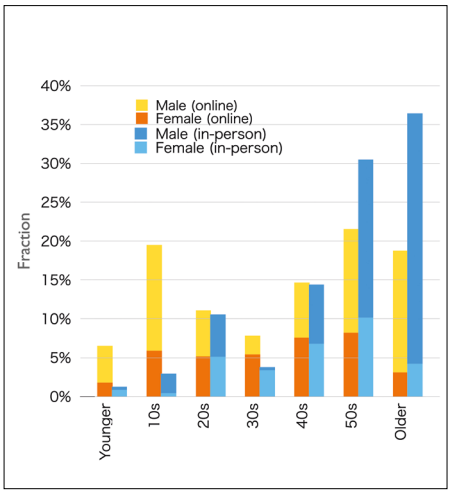

Figure 12: *Comparison of the age and gender distributions between the in-person (light blue and blue bars) public lecture and the average data over all webinars in 2021 and 2022 (yellow and orange bars). The in-person public lecture was held on 2 February 2020, with 237 respondents. The lecturer provided the data from the in-person lecture.*

significantly longer than the preferences indicated by the webinar attendees, suggesting that online attendees may have different preferences in presentation length compared to in-person attendees.

Discussion and future directions

In this article, we have demonstrated that hosting public lectures online is promising for reaching teens and women. Additionally, online outreach activities are more convenient for people in remote regions, allowing them to familiarise themselves with astronomy. In our 2021 and 2022 webinars, we observed nationwide participation. Although over 60% of attendees were from the Greater Tokyo Metropolitan area, the most populated area in Japan, there were also attendees from other parts of the country. This result highlights one of the primary advantages of online events: the ability for people to join from anywhere. Some attendees even sent messages after the webinars, expressing their gratitude for the opportunity to participate despite living in remote areas or far from where such events are typically held. Thus, online delivery of science talks enables broader inclusion.

As noted, attendees asked numerous questions during the webinars, and post-surveys indicated that the majority were satisfied with the length of the Q&A sessions, suggesting they found them enjoyable and informative. Studies on online learning (e.g., *Muzammil et al., 2020*) reported that interaction among attendees (including teachers) and interaction with content positively impact engagement. Therefore, active interaction using text tools and verbal communication may be vital in enhancing engagement and satisfaction among webinar attendees. Further studies are necessary to understand how interaction affects attendees' engagement and satisfaction. Additionally, it is important to explore whether engagement and satisfaction vary based on communication methods, such as text-based tools versus verbal communication.

All six webinars were recorded, and five were posted on YouTube after editing to protect participants' personal information and enhance the presentations with additional images. We found that the archived and posted videos reached at least 25 times more people. Publishing recordings online improves accessibility by allowing people to watch at their convenience, regardless of time or location. This on-demand distribution of science talks can improve inclusion by providing access to those who might be less able or willing to attend in-person events due to costs, caregiving responsibilities, or environmental concerns.

While our results show statistical significance, it is important to note the limitation of our small sample size. Future studies will be necessary to confirm if webinars can appeal to a broader audience. Based on our analysis of the feedback from online webinar attendees, a shorter presentation (e.g., 20 minutes) appears preferable for online lectures. However, this conclusion is drawn from data collected solely from online lectures and does not include a direct comparison with in-person public lectures. Future research should investigate this preference by comparing attendee responses from online and in-person formats.

Additionally, it is worth noting that all respondents in our survey were Japanese. Further research must examine whether these findings hold true in other countries and cultures.

Below are some takeaways for future online public lectures:

- Encourage attendees to ask questions and send comments. Dialogue between scientists and audiences helps to deepen understanding of the topic.
- Publishing recorded videos online can extend the reach of scientific content to an even broader audience.

In this report, we focused solely on lecture-type outreach activities. However, there are various other types of outreach activities, such as stargazing and hands-on workshops. Studies on different outreach activities, both online and in-person, will be essential to determine the optimal mode for each type of activity. Given that people have experienced a shift to online activities amid the COVID-19 pandemic, future research should focus on comparing online and in-person outreach activities to enhance and improve future outreach efforts.

References:

Editorial Board (2022). The consequences of conferencing. *Nature Astronomy, 6*(7), 763–763. https://doi.org/10.1038/s41550-022-01749-1

Brucks, M. S., & Levav, J. (2022). Virtual communication curbs creative idea generation. *Nature, 605*(7908), 108–112. https://doi.org/10.1038/s41586-022-04643-y

Christoph, J., & Hüttemeister, S. (2021). 'Planetarium@home': Digital astronomy outreach during the Covid-19 pandemic. *Communicating Astronomy with the Public Journal, 30*, 38–42. https://www.capjournal.org/issues/30/30_38.php

Dew, M., Ford, L., Nodurft, D. T., Erukhimova, T., & Perry, J. (2021). Student responses to changes in introductory physics learning due to the COVID-19 pandemic. *The Physics Teacher, 59*, 162–165. https://doi.org/10.1119/5.0027816

Massey, R. (2021). Life after Covid. *Astronomy & Geophysics, 62*(2) 2.32–2.33, https://doi.org/10.1093/astrogeo/atab057

Köhler, J. K., Kreil, A. S., Wenger, A., Darmandieu, A., Graves, C., Haugestad, C. A. P., Holzen, V., Keller, E., Lloyd, S., Marczak, M., Međugorac, V., & Rosa, C. D. (2022). The need for sustainability, equity, and international exchange: Perspectives of early career environmental psychologists on the future of conferences. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.906108

Krosnick, J. A., & Fabrigar, L. R. (2016). Survey measurement and process quality. In L. Lyberg, P. Biemer, M. Collins, E. De Leeuw, C. Dippo, N. Schwarz, & D. Trewin (Eds.), *Survey Measurement and Process Quality,* pp. 141–164. Wiley. https://doi.org/10.1002/9781118490013.ch6

Ministry of Internal Affairs of Japan (2021). *Information and communications in Japan white paper 2021.* https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/whitepaper/2021/index.html

Penteado, E. M., Spinelli, P. F., do Nascimento, W. R. S., de Lima, G. K., do Nascimento, J. O., Carrelli, F., & Cortesi, A. (2021). What to do in extreme times? An analysis of the astronomy communication actions in Brazil during the COVID-19 pandemic. *Communicating Astronomy with the Public Journal, 30*, 6–16. https://www.capjournal.org/issues/30/30_06.php

Moss, V. A., Adcock, M., Hotan, A. W., Kobayashi, R., Rees, G. A., Siégel, C., Tremblay, C. D. & Trenham, C. E. (2021). Forging a path to a better normal for conferences and collaboration. *Nature Astronomy*, *5*(3), 213–216. https://doi.org/10.1038/s41550-021-01325-z

Muzammıl, M., Sutawıjaya, A., & Harsası, M. (2020). Investigating student satisfaction in online learning: The role of student interaction and engagement in distance learning university. *Turkish Online Journal of Distance Education, 21*(Special Issue-IODL), 88–96. https://doi.org/10.17718/tojde.770928

Radin, A. G. B., & Light, C. J. (2022). TikTok: An emergent opportunity for teaching and learning science communication online. *Journal of Microbiology & Biology Education*, *23*(1). https://doi.org/10.1128/jmbe.00236-21

Roche, J., Bell, L., Hurley, M., D'Arcy, G., Owens, B., Jensen, A. M., Jensen, E. A., Gonzalez, J. R., & Russo, P. (2021). A place for space: The shift to online space education during a global pandemic. *Frontiers in Environmental Science, 9*(662947). https://doi.org/10.3389/fenvs.2021.662947

Sarabipour, S., Khan, A., Seah, Y. F. S., Mwakilili, A. D., Mumoki, F. N., Sáez, P. J., Schwessinger, B., Debat, H. J., & Mestrovic, T. (2021). Changing scientific meetings for the better. *Nature Human Behaviour, 5*(3), 296–300. https://doi.org/10.1038/s41562-021-01067-y

Skiles, M., Yang, E., Reshef, O., Muñoz, D. R., Cintron, D., Lind, M. L., Rush, A., Calleja, P. P., Nerenberg, R., Armani, A., Faust, K. M., & Kumar, M. (2021). Conference demographics and footprint changed by virtual platforms. *Nature Sustainability, 5*(2), 149–156. https://doi.org/10.1038/s41893-021-00823-2

van der Wal, J. E. M., Spottiswoode, C. N., & Sugasawa, S. (2022). Opportunities and risks of publishing academic talks online. *Nature Ecology & Evolution, 6*, 830–831. https://doi.org/10.1038/s41559-022-01755-6

Wu, J., Rajesh, A., Huang, Y.-N., Chhugani, K., Acharya, R., Peng, K., Johnson, R. D., Fiscutean, A., Robles-Espinoza, C. D., Vega, F. M. D. L., Bao, R., & Mangul, S. (2022). Virtual meetings promise to eliminate geographical and administrative barriers and increase accessibility, diversity and inclusivity. *Nature Biotechnology, 40*(1), 133–137. https://doi.org/10.1038/s41587-021-01176-z

Acknowledgements:

The author acknowledges Dr Masaaki Hiramatsu, who planned and carried out these webinars and the in-person lecture with the author. The Graduate University for Advanced Studies, SOKENDAI, supported the webinars discussed in this study. We used Exoratory for the statistical analysis in this report.

Biography

Chisato Ikuta is an Institute of Space and Astronautical Science (ISAS) associate professor at Japan Aerospace Exploration Agency (JAXA) and the Graduate University for Advanced Studies. She has more than ten years of experience in public outreach at National research institutes in Japan.