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Communicating Discovery Science

PRACTICE INSIGHTS

Enhancing public engagement and science communication through participatory astronomy: insights from the Surabaya Astronomy Club's star party model

Muchammad Toyib, Gebrina Ayu Pramesti and Nuri Herachwati

Abstract

This practice insight examines the Surabaya Astronomy Club (SAC) and its innovative approach to science communication and public engagement in Indonesia. Through organized star parties and community outreach, SAC leverages astronomy to foster public interest and enhance scientific literacy. The club's activities are deeply influenced by Indonesia's cultural and social context, emphasizing communal participation and integrating scientific phenomena with traditional and religious practices. Despite its successes, SAC faces challenges such as limited resources and the need for more systematic evaluation. Recommendations for improvement include expanding resource acquisition, adopting robust evaluation methodologies, enhancing inclusivity, and maintaining high-quality engagement. By partnering with governmental bodies and community organizations, SAC bridges the gap between scientific knowledge and public policy, demonstrating astronomy's relevance to societal issues and fostering a more informed and engaged public.

Keywords

Diversity, equity, inclusion and accessibility in science communication; Popularization of science and technology; Public engagement with science and technology

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1 ▪ Introduction

The Surabaya Astronomy Club, or SAC, is an amateur astronomy community based in Surabaya, East Java, Indonesia — the "City of Heroes." It was established on 8 September 2006. Notwithstanding its name, which relates the city of Surabaya, SAC also attracts club members from beyond the city limits. SAC is one of the amateur astronomy clubs in Indonesia, which has received international recognition from organizations such as NASA and IAU for activities done internationally, including International Observe the Moon Night and World Space Week, among others. In terms of membership, the SAC's WhatsApp group members consist of more than 200 people from all over Indonesia. Usually, around 30 participate in any given activity supported by the SAC. The club members span wide age differences; however, the majority consists of students. Their activities frequently take place at the coast around 10 kilometers from the city center to avoid the urban dynamic to conduct astronomy activities. Founded to promote interest in astronomy, SAC organizes a range of activities such as night sky observations and workshops that sow the seeds of scientific inquiry in people of all ages and backgrounds.

SAC extends its reach through digital platforms and raises Science, Technology, Engineering, and Mathematics (STEM) education and scientific literacy for K-12 students. Upholding the motto "Astronomy is not Expensive," SAC champions the cause by making astronomy accessible with the creation of cheap astronomical tools, plus debunking societal myths. The club envisions a science park in Surabaya, hoping it will spark interest in astronomy and eventually bridge gaps in public understanding. SAC believes that astronomy holds broader relevance and accessibility in everyday life.

This commitment to foster scientific interest aligns with the general definition of an amateur astronomer as a person with a passion for astronomy who practices it as a pastime. Professionals are people who are paid to do their work. Williams [1988] further clarified this distinction at the IAU colloquium 98 emphasizing that amateur astronomers are characterized by high skill levels and dedication to astronomy without any thought of financial gain [Percy, 2011]. In that line, SAC's efforts in popularizing astronomy not only gel with the spirit of amateur astronomy but can also contribute to a new generation of amateur astronomers being fostered who can later be on board with the large astronomical community.

Star parties as organised by SAC, may be a vehicle for tapping into local communities' potential. Star parties, while facing their own sets of challenges brought about by urbanization, offer ways of reaching out to the public so that they become closer to the celestial sphere and take curiosity to heart. Can star parties be validated as tools for social change? This practice insight seeks to advance the understanding of how astronomy, science communication, and engagement of the public may come together to solve societal challenges.

2 ▪ Amateur astronomy in Indonesia: challenges and opportunities

There is a huge gap across high schools in Indonesia, as well as in other levels of education, concerning the differences in knowledge sharing, skills, and competitive opportunities that

students are awarded. The gap is in violation of the Indonesian constitution that stands for ensuring equality in educational opportunities, improving the quality of education, and making the management of education relevant and efficient to serve the varied demands of an ever-changing society. Although interest in astronomy appears to be growing in Indonesia, as reflected by the increasing number of students enrolling in astronomy programs at the Bandung Institute of Technology (ITB), it remains the only formal educational institution offering such programs in the country [Elzulfiah, Mahanti, Ramadhan & Nasbey, 2015].

The establishment of the program in atmospheric and planetary science at the Sumatra Institute of Technology (ITERA) in 2018 marks significant progress toward the expansion of study programs related to astronomy. Nevertheless, international initiatives including Global Hands-on Universe and the Galileo Teacher Training Program remains out of reach for Indonesia. These programs are designed to give educators the basic knowledge and skills in astronomy so they can teach it and conduct simple research. However, information spread in Indonesia was not well-disseminated, hence the low participation of teachers [Toyib, 2024; Yamani, 2011]. Therefore, few students possess a well-based education in astronomy. Supporting astronomical activities within schools is also inconsistent. Many schools do not even know that astronomy is part of the National Science Olympiad (OSN) [Elzulfiah et al., 2015].

Amateur astronomers thus became the last hope for bridging an existing gap, and with time, their role has expanded considerably more to include activities in educational and public outreach in addition to traditional observation. Their enthusiasm has been the driving force behind the popularity of astronomy, and future generations took it up with relish [Chester, 1991]. The progress in this line shows that there is a need for inclusive and collaborative science, where the amateurs have moved from being lonely stargazers to important collaborators in the field [Dunlop & Gerbaldi, 2012]. Their valuable contributions, however, will face another challenge in the development of astronomy in Indonesia: urban light pollution.

Amateur astronomers have contributed much to the realm of astrophysical studies in the past and present, which has advanced the current problem of this environmental issue [Skarka & Kabáth, 2019]. That has affected the accessibility of dark sky environments that amateur practices enjoy and may even influence how they engage with the field. In addition, the dark sky is well preserved in line with the principles of sustainable tourism initiated by the government of Indonesia, culminating in the development of astronomy tourism (astrotourism) [Lemy, Teguh & Pramezwary, 2019].

Astrotourism generates significant economic benefits and employment opportunities for astronomers, science communicators, tour guides and astrophotographers, collectively stimulating local businesses such as hotels, travel agencies and restaurants. But these potentials remain largely untapped by lack of awareness regarding best practices; it necessitates targeted advocacy programs towards this end by the leaders of astronomical organizations [Yuna, 2018].

Some challenges are the absence of formal mechanisms for knowledge sharing, both within and outside the community, and cultural practices that engender the same [Yasrina et al., 2021]. In this context, the gap contrasts with the academic achievements of Indonesian youth in astronomy, which underlines a call for an increase in public outreach and resources at the disposal of the public in the Indonesian language [Yamani, Baskoro & Pramesti, 2008]. Therefore, the low participation of members of organizations in astrotourism projects

reflects a broader insufficiency in motivational leadership which hinders the formation of a collaborative culture and effective knowledge sharing [Elzulfiah et al., 2015; Yasrina et al., 2021; Yuna, 2018].

By popularizing science in general and astronomy in particular, amateur astronomy communities promote critical thinking and communal solidarity, hence creativity and innovation [Toyib & Yusuf, 2021]. These groups not only bridge educational gaps, especially among the most disadvantaged sectors of society, but their activities also form an alternative educational resource [Baldridge, Beck, Medina & Reeves, 2017]. Their non-formal initiatives bridge the gap in astronomy knowledge and provide a way of enhancing the quality of human resources through a deeper understanding of scientific principles and fostering critical thinking and even leadership skills. Even more, communities of this kind play a pioneering role in developing a science-aware ecosystem, which is important for the public's critical analysis of social phenomena.

3 ▪ Star party for enhancing public engagement and understanding of discovery science

Astronomy in Indonesia is often viewed as a scientific field instead of a tool for communication. However, the findings of a focus group discussion with the East Java Amateur Astronomer Communication Forum (FOKALIS JATIM) suggest that astronomy can serve as a medium for connecting communities and creatively expressing regional potential.

Figure 1. FGD of the Amateur Astronomy Community in East Java on April 13, 2019 which also involved elements of the Pasuruan National Institute of Aeronautics and Space (LAPAN Pasuruan) as the initiator.

In Surabaya and East Java, astronomy has become an empowering tool that enables communities to explore and articulate ideas, issues, and potentials within their environment.

The empowerment process by means of astronomy follows the steps of initiation, generation of educational messages, definition of the intended impact, problem mapping, cooperation with other stakeholders, and finally, publication. More importantly, this allows for openness and dialogue in responding to problems or solutions. Following these initial steps, the process goes further into public outreach and evaluation stages. Astronomy educates the public about environmental and scientific matters, or approaches them with solutions. The schema below represents this entire holistic process.

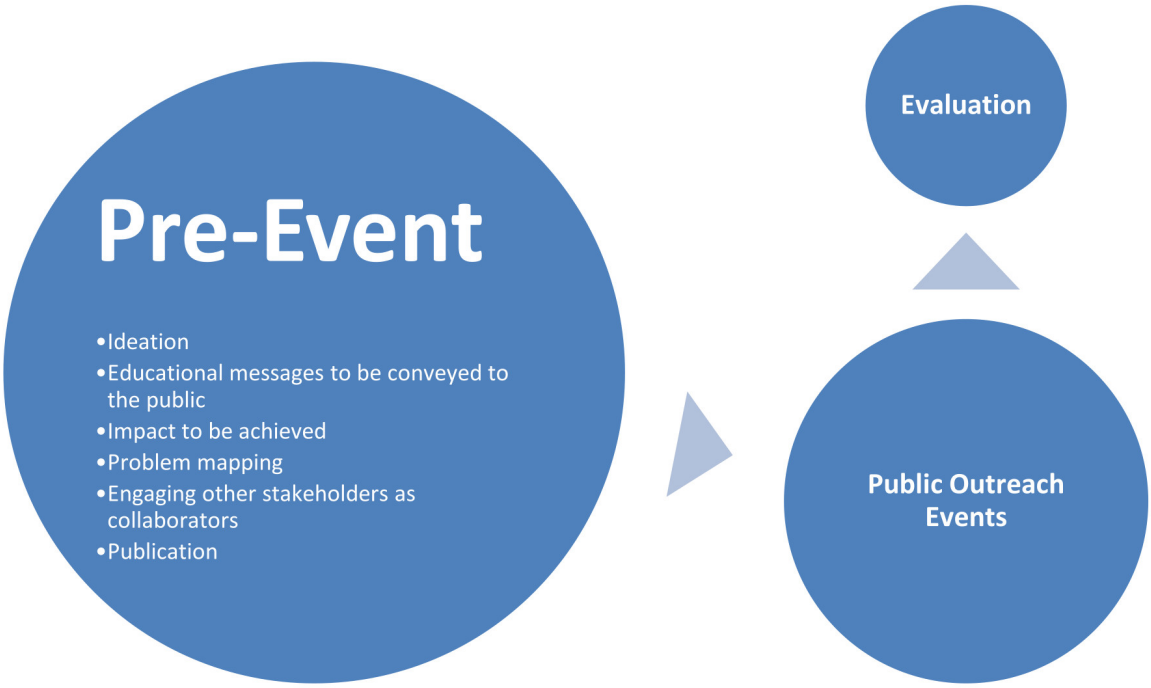

Figure 2. Process of Involving Astronomy as Part of Public Engagement and Empowerment.

The pre-event phase for SAC involves strategic selection, which is directed towards determining the event's format, i.e., star party, seminar, or workshop, relative to the target audience and relating astronomical phenomena. This process begins with a comprehensive examination of the year's astronomical calendar so that significant celestial events like planetary alignments, meteor showers, and eclipses, which will enhance the visual presentation and learning experience, are identified. SAC thus highlights events that also bring in not only observational but also thematic enrichment integrated within a broader educational or cultural narrative, for example, environmental conservation.

The planning also involves the evaluation of visibility and accessibility from Surabaya that assures the best observation conditions by addressing logistics, such as electricity supply, location permits, and weather contingency among others. SAC further involves coordinating with schools and other social groups to improve the contents of the outreach programs to expand their effects. This is mainly achieved through combined functions with institutions which always include the incorporation of astronomy in education. SAC has strengthened critical collaborations with government agencies and public observatories, notably with LAPAN, to enhance public engagement during crucial astronomical events such as eclipses and hilal observations. The resources and communication channels available at LAPAN are used to further extend public outreach through these partnerships. SAC has also joined

Figure 3. Astronomy Goes to School activities at Assaadah High School, Gresik, the collaboration between Surabaya Astronomy Club and the Faculty of Teacher Training and Education, Widya Mandala Catholic University Surabaya.

hands with IAU and the Network of Astronomy School Education (NASE) to enable it to access materials for use in education, which promotes cultural interaction in the form of exchange programs and research in collaboration with institutions from other countries. Strategic alliances have enabled SAC to receive financial grants because the institution keys itself strategically with organizations whose missions resonate with its own goals and objectives are geared towards achieving SAC's own goals and objectives. By presenting compelling proposals and emphasizing mutual benefits, SAC successfully attracts sponsors to support its educational and outreach programs.

The last step is publication, where SAC will circulate some materials in the form of flyers, banners, and/or short videos to invite public attention toward an event that is going to be held. Publication normally happens through community social media and the FOKALIS JATIM network. SAC will engage in these: Instagram and YouTube — visual content, small updates, and interesting videos tend to draw attention. The social media strategy for the club includes posts that regularly relate to the event, eye-catching facts of astronomy, and teasers that will help generate a series of tenterhooks in its excitement and anticipation.

SAC employs other traditional information dissemination channels, including flyers and posters distributed at the venue site of an activity for which permits have been secured. Such designs are always attractive and perfectly informative, often using strong images of celestial occurrences with clear, very succinct information about the event. It is the most convenient approach that assures availability and caters to those who may prefer to be informed in more traditional ways. In addition, SAC shares personal experiences and photos from past events, which helps to build a narrative that fosters deeper audience engagement. Integrating openness and deliberation is essential for any public outreach activity in astronomy, as it encourages involvement both during and after the event.

3.1 ▪ *"Cangkruk lan Ngamat"*

Astronomy serves as an empowerment tool through public outreach activities; a significant role can be given to star parties. Star parties provide an easy way to connect with many people and thus allow one to experience various open discussions. The SAC's star party events, called "*Cangkruk lan Ngamat*," Javanese for "Hang out and Observe", take place in crowded public places, along beaches, areas with less light pollution, or wherever celestial objects can be observed, depending on what is to be observed or the event being celebrated; all of this is decided in the preplanning phase before the event. To achieve an effective observation encounter, plan-

Figure 4. Bottom left is a poster for the "*Cangkruk lan Ngamat*" event, while the other picture is the atmosphere when the star party was held.

ning and execution of a perfect set-up and management of the telescope are very essential during the star parties at SAC. The process begins by selecting refractor, reflector, or compound telescopes that are suitable for observing specific celestial phenomena. Early on the day of the event, members of SAC set up and calibrate their telescope to ensure that it is aligned and tracking accurately as well as making sure that conditions permit viewing without too much light interference. Auxiliary tools such as binoculars and/or star charts are set up at assigned locations. Stationed operators assist attendees and continuously monitor and adjust equipment for any technical issues. Plugging in the power supply needs, portable generators or extra battery packs are used when needed, and backup plans for any unseen situations are made.

Star parties can be done in a more social and open environment, this makes a difference to the general format of teaching astronomy. However, there is an interesting correlation between astronomy and star parties specifically concerning community outreach and upliftment. Although star parties are a way of sharing opinions between community members, astronomy, as a concept itself, has the ability to not only engage the public but to empower it as well. The following model illustrates this relationship:

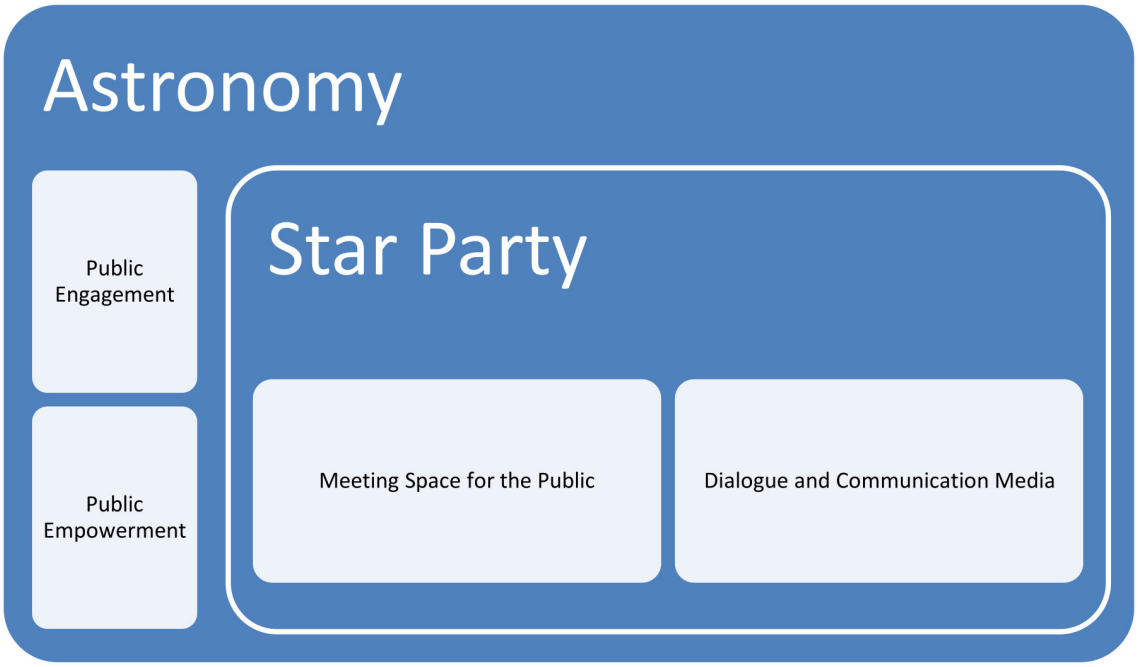

Figure 5. Astronomy and star party relations in the context of public engagement and empowerment by the Surabaya Astronomy Club.

SAC has successfully gone beyond the conventional model of "teaching science" to a much more collaborative and participatory model for the communication of science and public engagement. While more conventional means often stress one-way transmission of information from experts to learners, the approach by SAC places an interactive and community-driven form of engagement at the heart. Core among these would be the star parties and other public outreach events, played out as forums of active participants in contrast to just passively viewing.

Through this approach of problem mapping and stakeholder engagement, SAC advocates for an inclusive and democratic model of science communication. Community members involved in the designing and planning of events experience the empowerment of people not only to democratize access to scientific knowledge but also to support and shape the public discourse on science. In this participatory model, a positive atmosphere beyond traditional science education is represented to reflect joint effort and community engagement in the integration of scientific research into everyday life [Verhoeff & Waarlo, 2013].

4 ▪ Evaluation process

The SAC has actively engaged in reflective practices to evaluate the effectiveness of its programs and initiatives. This self-reflection encompasses a thorough review of the event's objectives, methodologies, and overall impact on the community. During star party events, SAC integrates both formal and informal methods to capture a comprehensive range of audience inputs.

During SAC's events, casual chats with guests offer quick feedback on their experiences. This allows for on-the-spot changes and shows how the event affects people's interest in and

understanding of astronomy. Participants report increased curiosity and a better understanding of scientific concepts, aligning with SAC's goal of enhancing science literacy. These check if the info is clear and well-communicated. To determine success, SAC looks at numbers like how many people show up and how diverse they are. They also examine how involved people get and how much they stay interested in astronomy over time. Feedback indicates that people enjoy hands-on activities; however, challenges remain, such as insufficient materials for participants to work with. To address these issues, SAC has established partnerships with related institutions, which have expanded resource access and integrated astronomy into their nature, enhancing both outreach and educational impact.

5 ▪ Implications for science communication and public engagement

Recent theories in science communication have emphasized a departure from the traditional methods, which primarily involve disseminating ideas from authorities to the public. These favor more interactive and dialogic approaches. According to empirical research, a consensus between scientific experts and the public needs to be reached. It is beyond the deficit model, which views the public as a passive audience who are given information, to a dialogue-encouraging model of participation. This shift steers open science into a more inclusive focus on education of audiences and the raising of awareness on scientific issues [Lee & VanDyke, 2015; Nerghes, Mulder & Lee, 2022]. The change is fed by research and empirical studies that put emphasis on the role of scientific discourses in increasing public understanding, trust, and legitimacy of scientific methods [van der Sanden & Meijman, 2008; Verhoeff & Waarlo, 2013]. The efforts of SAC therefore enrich these ideas by making astronomy not merely accessible but meaningful in activities that make it participative and discursive. Whether through outreach events such as star parties directly to the public or workshops, the methods of SAC are aligned with contemporary trends favoring active talking and doing over merely informing [Taddicken, Fick & Wicke, 2024; Yuan et al., 2017]. While the turnout at these events has been building up slowly, it is now becoming more regular — an indication of a growing interest from the community that proves SAC is doing something right in its approach to connecting with diverse audiences.

SAC's programs have deepened the public's understanding of scientific issues, characterized by diversified understanding from threats to consequences. Meetings often center on discussions about social issues and the impact of astronomy on these topics, such as light pollution. Discussions from participants are always focused on a deeper understanding of concepts and their relevance to life. SAC diffuses the knowledge about astronomical phenomena, especially the "unconventional" ones, taking away the scientistic vision of science as fundamental and promoting the circulation of knowledge. This opens, at the same time, different possibilities for astronomy to be a tool for communication between people and cultures. Events, such as the SAC "Cangkruk lan Ngamat" star party, provide a platform for free and public discourse in the meaning described by Jürgen Habermas: civil discourse, a language not obstructed by restrictions where participants have equal chances to act [Arifianto & Muktaf, 2019]. This project is not only an attempt to raise public awareness of astronomical issues but also relies on public understanding and participation. The renowned SAC program is designed to combine research and community engagement, creating an environment where astronomy will have a purpose that goes beyond traditional academic

boundaries. In addition, SAC's collaboration with governments, such as the Regional

Figure 6. The hearing process between FOKALIS JATIM (including SAC) and the East Java Regional People's Representative Body regarding scientific issues in East Java province.

People's Representative Body has opened up opportunities for broader discussions on social and scientific issues. This way, SAC bridges the gap between science and public policy by highlighting how current social issues relate to astronomy. In that sense, the grassroots membership of SAC strengthens the influence of star parties in society. Collaborations with local NGOs and other institutions in public service offer common problem solution impacting on social cohesion. For example, SAC often coincides star parties with the Earth Hour community to campaign on issues such as light pollution and/or environmental protection.

6 ▪ Challenges and areas for improvement

SAC practices are largely influenced by the Indonesian cultural character and social structure. These factors include the strong sense of community in Indonesia, which believes in merits through communality and mutual support. This is highly manifested through the "*Cangkruk lan Ngamat*," where open and inclusive spaces from within the public are created to aid in the enhancing of social ties and collective learning. Another reason why the image of SAC is even more human at the face level concerns its self-adjustment to the different cultural norms of Indonesia, especially because the instillation of astronomical events into traditional and religious practices, such as hilal observations, facilitates. Social issues, such as gaps in education and disparity in resources, shape some of the most important factors in the workings of SAC. Such considerations of the issues raised were regarding inclusivity and accessibility that are well reflected in the use of equipment at affordable costs and setting up events in highly accessible locations.

Despite some obvious successes, SAC still faces numerous challenges due to lack of advanced equipment and educational materials. As such, there is an increased need for more funding and strategic partnerships involving academic and industry stakeholders. While feedback mechanisms might be useful, inbuilt systematic evaluations in the form of longitudinal studies would be needed to find out what impact on participants' knowledge and

attitudes such programs will really make over a longer period. Moreover, it is still incumbent to ensure further efforts at reaching out to those remaining underrepresented and marginalized in society with appropriate communication strategies, which will surmount barriers associated with prior exposure to scientific content. Last but not least, high-quality engagement in itself — continuously scaled out by the club — demands constant training for members and educators of the approach in order to remain updated with the very latest evolutions in science communication and changing public interests that SAC's approach must be able to adapt to.

7 ▪ Recommendations for organizations adopting similar models

In this practice insight, the first author, who serves both as a member and Secretary-General of SAC, provides an insider's view with respect to the internal dynamics of the club. In attaining high levels of detail on insights pertaining to SAC's operations, ranging from outreach events to the public, through community engagement to collaboration efforts, this firsthand experience comes in handy. The co-authors are the external observers, and with expertise in management and human resource development, they make a critical analysis in regard to aspects of SAC that are managerial and organizational. Their views further provide context to the initiatives taken up in SAC within the broader educational and organizational theories available on the issues of public engagement and science communication.

Drawing on SAC's experience, some of the key recommendations for organizations intending to implement a similar model of science communication and public engagement are:

1. *Emphasize Accessibility and Inclusivity.*
   Science should be accessible to everyone. It is important not to portray science as exclusive to the elite or prohibitively expensive, as this can deter many potential participants. Low or no costs for events, materials, and equipment can make a big difference in engaging normally underrepresented groups.
2. *Design Participatory Experiences.*
   People relate much better to science when they have a chance to experience it for themselves. Consider organizing star parties or hands-on workshops where citizens can come together to engage with experts. It bridges the gap between science and society.
3. *Leverage Digital Platforms.*
   A strong presence on the web is essential. Indeed, websites, social media, and virtual events can greatly expand your reach particularly among youth and individuals living in remote areas who may not have the means to attend in person.
4. *Foster Collaboration and Partnerships.*
   Relationships with academic institutions, government agencies, non-profits, and industry stakeholders can help leverage resources to have a more significant impact on topics relevant to the organization. These partnerships can increase the usage of state-of-the-art equipment, speakers, and additional money needed for outreach activities.

5. *Institute Comprehensive Evaluation Mechanisms*.
   Evaluate the effectiveness of the outreach programs. Quantitative and qualitative research, carried out using surveys and interviews, will achieve an apprehension of the long-term effects and help in deciding future programs.
6. *Establish Continuous Learning*.
   Provide continuing professional development for members and volunteers. Keeping up to date with the best practice in science communication, and remaining responsive to feedback, will help the organization to keep learning about how to continually improve the approach.
7. *Highlight the Broader Relevance of Science*.
   Connect scientific ideas with the relevant contemporary issues, such as environmental sustainability and health. This approach gives clarity on how science works towards solving global problems and improving life's quality.

8 ▪ Conclusion

Of the many activities that SAC organizes, there is a record of such attention showing in star parties for other organizations interested in science communication and, more generally, science education. Among the most important strategies that can be mobilized to engage diverse audiences in meaningful ways are paying attention to issues of accessibility, creating engaging activity experiences, taking advantage of digital platforms, building collaborations, setting up effective and robust means of evaluation, encouraging learning as an ongoing process, and highlighting the wide relevance of science for a more scientifically literate and empowered society. These recommendations and practice insight thus provide a framework for developing outreach programs that are both sustainable and impactful in a manner that not only instills knowledge and communicates science but also inspires curiosity, critical thinking, and the further empowerment of society.

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About the authors

Muchammad Toyib, an amateur astronomer and science communicator, merges his diverse background in law and agrotechnology with his passion for astronomy. He is pursuing a Master's in Human Resource Development at Postgraduate School, Universitas Airlangga. As Secretary-General of the Surabaya Astronomy Club and former chair of the East Java Amateur Astronomer Communication Forum (FOKALIS JATIM), he plays a key role in popularizing astronomy and science communication in East Java, Indonesia.

muchammad.toyib-2023@pasca.unair.ac.id
@thoyibas

Gebrina Ayu Pramesti is a human resource management expert with a bachelor's degree from Universitas Airlangga (UNAIR), a master's from Sepuluh Nopember Institute of Technology, and is pursuing a doctorate at Universitas Airlangga. Active in HR projects since 2015, she specializes in remuneration systems and Workload Analysis. Currently, she tutors thesis proposal writing in the HRD department, at the postgraduate school UNAIR, and teaches compensation and performance management as a non-permanent lecturer in the Bachelor of Management program at UNAIR.

gebrina.ayu.pramesti-2022@feb.unair.ac.id

Nuri Herachwati is a prominent academic in Human Resources Management, holding degrees from Universitas Airlangga and Strathclyde University. She earned a Best Paper Award at the 2017 International Conference on Organizations and Innovations in China. She is a member of the Indonesian Economics Bachelor Association, serves as Secretary of the Indonesia Management Forum, and is Vice President of the Roundtable Entrepreneur Educators Indonesia. Currently, she serves as a lecturer and head of the HRD Masters study program at the Postgraduate School, UNAIR. Her teaching focuses on HRM, Organization Development, and Entrepreneurship.

nuri-h@feb.unair.ac.id

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