Design, implementation and evaluation of transnational collaborative programmes in astronomy education and public outreach

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II

Innovation in Global Science Education and Public Outreach Programmes

II.1

The International Year of Astronomy 2009 as a Massive Science Communication Project

The International Year of Astronomy 2009 (IYA2009) was the largest ever science communication project, with more than 815 million people participating from 148 countries. IYA2009 was declared by the United Nations General Assembly and officially ratified by UNESCO, the International Astronomical Union and the International Council of Science. Here we describe and analyse IYA2009 as an example of a successful massive science communication project (MSCP) and draw lessons that are relevant to the design and implementation of future large global science communication projects. We provide an account of IYA2009 from its inception to its legacy; discuss the goals, objectives, results and impact of the project; and compare them to those of other UN-endorsed scientific years. The importance of coordination in ensuring the success of an MSCP is emphasised. We also consider the influence that the legacy of IYA2009 has had on astronomy education and public outreach globally. The project has demonstrated that there are diverse ways to engage the public using astronomy. A unique aspect of IYA2009, which proved vital in ensuring its large reach, was the exploitation of non-professional astronomers for various levels of engagement. A limitation of the project was the absence of the key component of long-term evaluation. We describe and discuss lessons learned from IYA2009 that are relevant to future global MSCPs. These lessons are particularly relevant for the organisation of the International Year of Light and Light-based Technologies in 2015 and other upcoming science-related International Years or International Years of Science (IYSs).

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1. Introduction

Astronomy is one of the oldest fundamental sciences, and it continues to have a profound impact on human culture (Rosenberg, Russo, Bladon, & Christensen, 2014). As a research field, it has witnessed several major scientific breakthroughs in the last century that can be used to interest and intrigue non-professional astronomers (Hughes, 2007). One hundred years ago, we were ignorant of the nature of the Milky Way; but today, we understand that many billions of galaxies make up our Universe and that it originated approximately 13.8 billion years ago (Ade et al., 2013). One hundred years ago, we did not know whether our solar system was unique, but in the last two decades, astronomical facilities have detected almost 2000 planets revolving around other stars in the Milky Way (Schneider, Dedieu, Sidaner, Savalle, & Zolotukhin, 2011), and we are exploring the possibility that life originated beyond our solar system. One hundred years ago, we studied the sky using only optical telescopes and photographic plates; today we use the complete electromagnetic spectrum, from radio waves to gamma rays, to observe the Universe from Earth and from space. Such advances in astronomy have changed the perception of our place in the cosmos, and stimulated the interest of the public in science (Christensen & Russo, 2007). The media attention given to astronomical topics in most developed countries evinces this interest (Bauer, 2013; Sjøberg & Schreiner, 2010; Zuluaga, 2014).

The International Astronomical Union (IAU) organised the International Year of Astronomy 2009 (IYA2009) to exploit this widespread interest in astronomy among a large section of the public (Russo & Christensen, 2010) and to provide the first contact with inspirational science for others (Hesser et al., 2010). In this chapter, we discuss IYA2009 in detail as an example of an innovative global science communication project. Besides describing the goals and objectives, we also discuss the results and impact of the project and, where possible, compare the organisation of IYA2009 with those of other UN-endorsed scientific years. We will then generalise the experience with IYA2009 to apply it in the design and implementation of future large science communication projects.

1.1. International Years of Science as global massive science communication projects

IYA2009 is an example of a massive science communication project (MSCP). Similar to a massive open online course (MOOC), an MSCP is designed for the participation of large numbers of geographically dispersed people. The most prominent examples of global MSCPs are the International Years of Science (IYSs). IYA2009 built upon previous IYSs and included several additional innovative aspects. We shall here consider the history and elements of previous IYSs.

The IYSs have a long and varied history (see Table 2), from the first International Polar Year in 1882/1883 (Baker, 1982) to its modern versions such as the International Heliophysical Year in 2007/2008 (Thompson, Gopalswamy, Davila, & Haubold, 2009). These previous projects provided the necessary framework for holding IYA2009 (Russo, Cesarsky, & Christensen, 2009). Every project begins with a concept and the justification for it. The concept should

capture people's imaginations, be relevant to society, and ideally have the potential to continue beyond the year in question. It is also necessary to build a case that will persuade policymakers of the value of having a year dedicated to a specific theme. For an official international year, recommendation from a UN specialized agency is necessary before seeking the final official step of a UN proclamation (see Table 3). For science-related years, the relevant UN agency is the United Nations Educational, Scientific and Cultural Organisation (UNESCO). To achieve global reach, the IYS organisation needs to work with a large network or networks that ideally already exist and can serve as the foundation upon which to build. There must be ideas for national and world-wide activities, as well as the funds to implement these. Finally, enthusiasm, engagement and excitement from all involved stakeholders are necessary.

Although a number of IYSs have been held in the past, little has been done towards the evaluation or assessment of these events. This makes it difficult to compare IYA2009 with other similar projects and demonstrates the need to create a baseline to which the impact of future International Years or other MSCPs can be compared. The participation of large numbers of geographically dispersed people in a diverse number of projects makes the evaluation of such projects a difficult task. Other constraints that impede proper assessment are the lack of clear objectives, no common language for the projects, the absence of an evaluation framework, and the dearth of evaluation professionals. A part of this chapter presents the first attempt to define and perform a quantitative and, to a certain extent, qualitative analysis of an MSCP. In the Evaluation section, we discuss the participation numbers of IYA2009, the levels of engagement of these participants in IYA2009-related activities and their relevance to the evaluation of other IYSs.

Table 1. Science-related International Years

Year(s)	**International Observance**	**Scope**	**Reference**	**Number of Countries and International Organisations involved**
1882/1883	International Polar Year	Research-oriented	Baker, F. W. G. (1982). The first international polar year, 1882–83. Polar Record, 21(132), 275–285.	Not available

1932/1933	International Polar Year	Rese-arch-orien-ted	Fleming, J. A. (1933). Progress report on the International Polar Year of 1932–33. Eos, Transactions American Geophy-sical Union, 14(1), 146–154.	Not availa-ble
1957/1958	International Geophysical Year	Rese-arch-orien-ted	Odishaw, H. (1959). International Geophysical Year. Science, 129, 14.	Not availa-ble
1961	International Health and Medical Re-search Year	Rese-arch-orien-ted	World Health Or-ganisation. (1959). International health and medical research year.	24 nations
1992	International Space Year	Public- and rese-arch-orien-ted	'Mission to Planet Earth'. United Na-tions Chronicle, 29 (4), 49.	29 national space agen-cies and 10 internatio-nal organi-sations
2005	World Year of Physics	Public- and rese-arch-orien-ted	Stone, C. (2004). The World Year of Physics in 2005. The Physics Tea-cher, 42(1), 18–23.	Not availa-ble
2007–2008–(2009)	International Polar Year	Public- and rese-arch-orien-ted	Committee on the Legacies and Lessons of Inter-national Polar Year 2007-2008, 2012, Lessons and Lega-cies of the Interna-tional Polar Year 2007-2008	60 nations
2007-2009	International Year of Pla-net Earth	Public- and rese-arch-orien-ted	Woodfork & de Muller, 2010, In-ternational Year of Planet Earth – Final Report	79 nations and 25 in-ternational organisa-tions
2009	Internatio-nal Year of Astronomy	Public-ori-ented	Russo & Christen-sen, 2010, Inter-national Year of Astronomy – Final Report	148 nations and 73 in-ternational organisa-tions

2010	International Year of Biodiversity	Public-oriented	Johns, D. (2010). The international year of biodiversity-from talk to action. Conservation Biology, 24(1), 338.	87 nations and 1 international organisation
2011	International Year of Chemistry	Public-oriented	Zolotov, Y. A. (2010). International year of chemistry. Journal of Analytical Chemistry, 65(8), 769–769.	Not available
2013	International Year of Crystallography	Public- and research-oriented	Desiraju, G. R. (2014). Celebrating the International Year of Crystallography 2014. Crystal Growth & Design, 14(1), 1–1.	52 nations
2015	International Year of Light and Light-based Technologies	Public-oriented	McKenna, J. (2014). A look ahead to the 2015 International Year of Light and Light-based Technologies. Journal of Optics, 16(12), 120201.	80 nations (as of March 2015)

2. IYA2009 – Case Study of an International Year of Science

In this section, we will discuss the various elements and procedures of IYA2009 to use it as a case study for designing and implementing an International Year of Science

2.1. Vision and goals

IYA2009 was a global project initiated by the IAU and UNESCO. The mission of IYA2009 was to '*help the citizens of the world rediscover their place in the Universe through the day- and night-time sky, and thereby engage a personal sense of wonder and discovery*' (Russo & Christensen, 2010). As later defined in the book *Learning Science in Informal Environments* (Bell, Lewenstein, Shouse, & Feder, 2009), IYA2009 used a framework of interrelated aspects of astronomy education and public outreach of astronomy to fulfil this mission. IAU and UNESCO defined the goals of IYA2009 (Russo & Christensen, 2010) taking in account the different levels of people's engagement with astronomy: developing interest in astronomy, understanding astronomy knowledge, engaging in scientific reasoning, reflecting on astronomy, engaging in practical aspects of astronomy, and identifying themselves with the astronomy enterprise (Table

2). IYA2009 was the first science-related international outreach project with such a defined public engagement framework.

Table 2. Overview of the IYA2009 public engagement framework

Goals	**Objectives**
1. Increase scientific awareness among the general public through the communication of scientific results in astronomy and related fields as well as the process of research and critical thinking that leads to these results.	Make astronomical breakthroughs more visible in the daily lives of billions of people through all available means of communication (e.g., TV/radio documentaries, newspapers, web pages, exhibitions, stamps, blogs, web portals, advertising campaigns, etc.). Facilitate opportunities for individual astronomical observations.
2. Promote widespread access to the universal knowledge of fundamental science by popularising astronomy and sky-observing experiences.	Enable as many laypeople as possible, especially children, to look at the sky through a telescope and gain a basic understanding of the Universe.
3. Empower astronomical communities in developing countries through the initiation and stimulation of international collaborations.	Involve astronomical communities of developing nations in the Year, thus providing examples of how outreach and education are carried out in different parts of the world.
4. Support and improve formal and informal science education in schools as well as in science centres, planetariums and museums.	Develop formal and informal educational material and distribute all over the world. Conduct focused training of event leaders and presenters.
5. Provide a modern image of science and scientists to reinforce the links between science education and science careers and stimulate a long-term increase in student enrolment in the fields of science and technology and an appreciation for lifelong learning.	Organise popular talks by scientists for people of every gender, age and ethnic background. Share profiles – on TV, in blogs, in biographies – of scientists who break the traditional 'lab coat' stereotype, by showing the excitement of scientific discovery, the international aspect of scientific collaborations and the social sides of scientists.

6. Facilitate new and strengthen existing networks by connecting amateur astronomers, educators, scientists and communication professionals through local, regional, national and international activities.	Connect as many individuals (named 'IYA ambassadors') as well as organisations (amateur and professional) in networks as possible, by creating, for instance, new internal and external electronic communication infrastructures. These networks will become part of the heritage of IYA2009.
7. Ensure gender-balanced representation of scientists at all levels and promote greater involvement of underrepresented minorities in scientific and engineering careers.	Provide access to excellent role models and mentors, formally and informally, and publicize them. Provide information about the female 'dual-career' problem and offer possible solutions.
8. Facilitate the preservation and protection of the world's cultural and natural heritage of dark skies in places such as urban oases, national parks and astronomical sites by spreading awareness about their importance in the natural environment.	Involve the dark-sky community in IYA2009. Collaborate for the implementation of the UNESCO and IAU 'Astronomical and World Heritage' initiative. Lobby with organisations and institutions as well as local, regional and national governments for the approval of preservation laws for dark skies and historical astronomical sites. Bring the issues of natural environment and energy preservation to the agendas of decision makers.

2.2. Setting up the project

Table 3. Key milestones leading up to the UN declaration of the IYA2009 resolution in December 2007

Year	Milestones
2002	The IAU presented the concept Italian astronomer and the then IAU president Franco Pacini (1939–2012) reasoned that as 2005 was set to be the World Year of Physics, there was potential for astronomy to achieve the same status in 2009, the year that marked 400 years of Galileo's achievements (Isidro, 2012).

2003	IAU General Assembly, Sydney IAU members voted unanimously in favour of Resolution IAU GA 2003 B3 (International Astronomical Union, 2003), which recommended that 2009, the 400th anniversary of Galileo's accomplishments and the birth of modern telescopic astronomy, be declared the Year of Astronomy.
2005	UNESCO endorsement The Italian Ambassador to UNESCO submitted a request to UNESCO. August 2005: UNESCO decided to endorse 2009 as the International Year of Astronomy (UNESCO, 2005).
2006	IAU General Assembly, Prague, Czech Republic A special session helped reinforce plans for IYA2009 that would be implemented in the event of a positive decision by the UN.
2007	To convince the UN that a particular topic deserves the International Year status, support from many countries is necessary. Lobbying took centre stage, with an IAU delegation (including the IAU president) presenting the project at the UN Headquarters in New York in mid-2007. December 2007: UN Proclamation On 17 December 2007, the UN accepted the recommendation, and 2009 was officially declared the International Year of Astronomy (United Nations, 2007).

The IYA2009 network and the importance of amateur astronomers. Once the UN proclamation was confirmed, the implementation was under way. For IYA2009, the IAU, in close collaboration with UNESCO, played the role of the central coordination body. However, the IAU had only 64 national members as against the 192 sovereign states recognized by the UN at the time. To involve as many countries as possible, the organisers first identified countries that counted professional astronomers. The organisers asked countries active in astronomy to support neighbouring nations that lacked experts and also sought support in identifying scientific communities from UNESCO delegations. Over time, the organisers amassed a long list of astronomy experts or high-level amateurs from nations around the globe. A unique aspect of astronomy as a tool for science communication is the presence of a large community of amateur astronomers, whose size exceeds that of the professional astronomical community by at least an order of magnitude (DeVoss, 1998). From the outset, the organisers of IYA2009 were keen to involve large numbers of these amateur astronomers. This decision ensured that the project would widen its global reach substantially. On the other hand the involvement of amateur astronomers posed the risk of undermining the scientific knowledge of some of those involved in the implementation of IYA2009. The organisers asked the local astronomy communities to designate a single point

of contact (SPoC), whose responsibility was to establish and lead an IYA2009 National Node. The membership of these National Nodes was very heterogeneous, with a typical composition consisting of senior professional astronomers (mainly IAU members), senior science communicators (science museum and planetarium directors, university press officers) and presidents of amateur astronomy societies. This distribution provided the National Nodes with the necessary astronomy background, scientific knowledge and access to networks and knowledge of public engagement projects to implement IYA2009 at national and local levels. The IYA2009 organisers established 148 National Nodes. During this phase of assessment and definition of the agents of IYA2009, several successful transnational science communication and education institutions joined IYA2009, and were designated as 'Organisational Nodes'. These institutions had the potential to lend their valuable expertise to the project by supporting and implementing activities in their communities and networks around the globe.

Designing IYA2009 as a global project. In 2003, the IAU established a Special Working Group (IAU IYA2009 WG 2007), which defined and oversaw the global implementation of IYA2009. The initial task of the IAU IYA2009 WG was to establish a rationale, a vision, goals and objectives. In 2006, the IAU IYA2009 WG also started planning some initial IYA2009 global projects, such as the Portal to the Universe (concept presented for the first time in the IAU GA in Prague) and the Cosmic Diary (initially presented in 2006 as The Universal Times). Further, the goals of the working group led to the establishment of specific cornerstone projects, including 'Dark Skies Awareness' and '100 Hours of Astronomy' (including 'Around the World in 80 Telescopes'). Drawing on different concepts and studies, the IAU IYA2009 WG also defined the final logo and slogan (The Universe, Yours to Discover) of the project in 2007. The organisers engaged the relevant astronomy communities through key meetings, such as the SPoCs' meeting in Germany in March 2007 (IYA2009 Meeting at ESO, 2007) and the Communicating Astronomy with the Public conference in October 2007 in Athens, Greece (Christensen, Zoulias, & Robson, 2007).

Setting up the global coordination. By July 2007, the IYA2009 Secretariat was established at the European Southern Observatory's Headquarters in Garching, near Munich in Germany. The secretariat was the central hub of IYA2009, coordinating activities during the planning, execution and evaluation phases. An important aspect of the secretariat's coordination function was that it aimed to support, not control. The secretariat acted as a catalyst and facilitator, providing a strong framework, strong standards and strong sets of procedures. It became evident that a central coordination office was an essential component for the organisation of science communication projects involving the participation of large numbers of geographically dispersed people, such as IYSs.

Fundraising. To raise funds, the organisers contacted organisations, institutions and agencies related to astronomy, space science and the natural sciences. They offered private companies the opportunity to become Global Official Partners or Global Sponsors. The strategy was to send a direct mail

initially and to then follow it up with personal calls to specific contacts and fundraisers (Russo & Christensen, 2008). As a result, 33 'Organisational Associates' agreed to provide financial backing, in addition to three Global Sponsors. Unfortunately, the organisers found no Global Official Partners, but they did raise a total of €650 000 for the implementation of the project through the IYA2009 Secretariat. The other IYA2009 stakeholder budgets, for the National Nodes, Organisational Nodes and global funding, amounted to at least €18 million – and this financial investment was complemented by large in-kind contributions from amateur and professional astronomers, educators and organisers who helped to run the events. By the end of 2007 and beginning of 2008, a significant amount of groundwork had been completed, and a clear vision of the Year was emerging.

2.3. Implementation

The IYA2009 was implemented at several levels: global, national, regional and local. Most of the events were organised locally and relied on local amateur and professional astronomers. However, an international network of interconnecting organising bodies ensured that the best ideas and practices were shared. In this section we present several examples of the implementation of different public engagement initiatives during IYA2009 at global and national levels. These initiatives were selected on the basis of their reach, relevance and originality (Table 4). A complete overview of the IYA2009 initiatives, including detailed information on individual projects and countries, can be found in Russo & Christensen (2010).

Table 4. Selected IYA2009 projects

IYA2009 Project	Scope	Reach	Highlights	Main IYA2009 Goals Attained (See Table 2)	References
Worldwide Star Parties	Global	At least three million people	100 Hours of Astronomy (April 2009) Galilean Nights (October 2009) Event at the US White House (October 2009) Many members of the public seeing celestial objects through a telescope for the first time. Around the World in 80 Telescopes, a live 24-hour webcast, which gave members of the public a snapshot of a day in the life of astronomical research observatories around the world.	1, 2, 3, 5,8	Pompea & Norman, 2009 Pierce-Price et al., 2009
From Earth to the Universe	Global	1000 locations in 70 countries and 10 million people viewed the exhibits, which were translated into 40 languages	Photographic exhibition, staged in unexpected and easily accessible locations, such as parks, metro stations, shopping malls, hospitals, libraries, and even prisons. The exhibition is held at venues around the world to this day.	1,3,5,6	Arcand & Watzke, 2010 Arcard & Watzke, 2011

Galileoscope	Global	110 000 of these educational telescope tools were distributed in 96 countries	A low-cost telescope educational kit that was specifically designed for IYA2009.	1,2,3, 4,6	Fienberg & Pompea, 2007 Bohannon, 2010
Transnational Educational Projects	Global	At least 3000 educators involved in these projects	Universe Awareness programme: targeting preschool and primary education. Galileo Teacher Training Programme: targeting secondary education	1,2,3,4 ,5,6,7	Ödman, 2007 Doran, 2010
Planetarium Shows	Global	85000 people	Three planetarium shows had a global impact: Two Small Pieces of Glass attracted 500 000 visitors; ALMA: The Search for our Cosmic Origins had over 250 000 viewers; and the ESA production Touching the Edge of the Universe had an audience of 100 000.	1,5,6	Russo & Christensen, 2010 Boffin, Acker, & de Langue Française, 2008 Habison, 2013
Large-Scale Models of the Solar System	National (Sweden and Finland)	Sweden and Finland with around 1000 000 people reached in both countries	The large, spherical Ericsson Globe Arena in central Stockholm represented the Sun and the planets were distributed through the country. The Sun was marked by a giant sticker in the busy Helsinki Central Railway Station and the planets were distributed across the rail line	1	Russo & Christensen, 2010

World's longest canvas with astronomical motifs	National (Portugal)	300 000 people	4.8 kilometre long canvas with astronomical motifs Guinness World Record	1	Frade, Doran, & Fernandes, 2011
Sky observations	National (Canada and Japan)	2 000 000 in Canada 7 000 000 in Japan	Two million people registered on the Canadian IYA2009 website to say they had experienced a 'Galileo moment' (observing through a telescope) In Japan, seven million people observed the night sky through a telescope during IYA2009	1,2,5	Percy, 2009 Sekiguchi, 2010
Parade	National (India)	700 million people	Indian astronomers showcased their work at the Republic Day parade in Delhi. With 30 000 people watching in person and an estimated 700 million watching on television	1,2,5	Russo & Christensen, 2010
Solar eclipse	National (South Korea)	400 000 people	A partial solar eclipse on 22 July was the highlight of the year, with viewing events held in 45 locations across the nation, attracting over 400 000 people, from kindergarten children to the president of the Republic of Korea	1,2,5	Seo-Gu, 2010

Astronomical Exhibition	National (USA)	100 planetariums, museums, nature centres and schools across the US	The Great Observatories Image Unveiling, NASA sent images to 100 planetariums, museums, nature centres and schools across the US to mark Galileo's birthday on 15 February	1,2,4,5	Summers, Smith, Stoke, Eisenhamer, & Team, G. O. I. U., 2008

The IYA2009 global projects received significant coverage in the 'new media': there were many reports on IYA2009 on the Web, including blog stories and social media mentions (Russo & Christensen, 2010). The Portal to the Universe website was the first one-stop shop for astronomy news and has had 800 000 visitors since its launch in April 2009. Cosmic Diary was a blog in which 60 professional astronomers from around the world wrote more than 2100 posts on their work, family life, friends and hobbies, attracting 250 000 visitors. The bloggers also produced feature articles about their areas of astronomy expertise, explaining complex ideas in easy-to-understand language. These features formed the basis of a published book, *Postcards from the Edge of the Universe* (Pullen, Barrosa, & Christensen, 2010), which served as a record of the project.

2.4. Impact

IYA2009 had 216 main stakeholders – 148 countries, 40 international organisations and 28 global projects. Only half of the stakeholder organisations (108) noted the number of people reached by their events and the budgets they had available to implement their activities. Funds equivalent to at least €18 million were devoted to IYA2009 activities – and large in-kind contributions from amateur and professional astronomers, educators and organisers, who helped to run the events, complemented this investment.

Table 4. Levels of engagement of non-scientists with astronomy during IYA2009

Levels of Engagement	**Examples of Activities**	**Aspect of Astronomy Learning in Informal Environments**
Informal Contact	Exhibits in non-traditional places and walk-ins News: TV news, generic newspapers/magazines, etc.	Developing interest in astronomy
Passive Participation	Expert talks Astronomy documentaries Specific exhibitions	Understanding some astronomical knowledge

Active Participation	Popular science books Workshops and hands-on exhibition Sky observation nights	Using scientific reasoning and reflecting on astronomy
Participation as data collectors and analysts: Citizen Science	Monitoring/ data collection by amateur astronomers Data analysis, e.g., Galaxy Zoo	Practicing astronomy
Amateur Researcher	Defining scientific questions Participation in the whole scientific process	Identifying with the astronomy enterprise

Different types of IYA2009 activities led to different levels of engagement of non-scientists with astronomy. These levels of engagement were linked closely with the aspects of learning science in informal environments, discussed by Bell et al. (2009). To develop a simplified definition of the level of engagement of non-scientists with astronomy, we can consider the degree of participation in IYA2009 activities by non-scientists, and a common metric of engagement is the quantifiable volume of activity (Zhang, Jiang, & Carroll, 2011). Table 4 below summarizes the levels of engagement of non-scientists with astronomy during IYA2009, and Figure 1 gives an overview of the distribution of projects sorted by level of engagement during IYA2009. We retrieved the activities from individual reports provided by the IYA2009 organisers (Russo & Christensen, 2010).

The reports provided show that IYA2009 activities reached at least 815 million people worldwide. Assuming that the reporting by stakeholders is truthful, the numbers reported make IYA2009 the world's largest science communication project (Russo & Christensen, 2010). In terms of global reach for a science outreach project, the impact of IYA2009 in engaging the public was larger than any event since the Apollo Moon programme 40 years before. At its peak in 1969, Neil Armstrong and Buzz Aldrin's first steps on the Moon

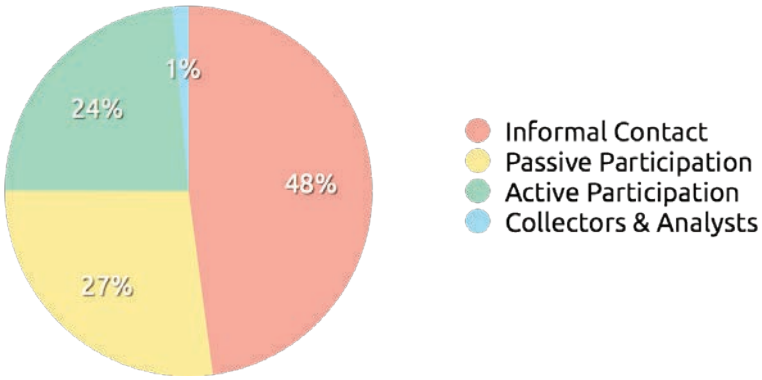

Fig 1 Percentage of people engaged in different levels with IYA2009 activities. The raw data can be found at www.goo.gl/gAAQIf.

reached an audience of more than a billion ('Apollo 11 Turns Out as Biggest Show on Earth,' 1969). Forty years later, IYA2009 reached a mass audience of at least 800 million people.

3. Discussion

Although many features of IYA2009 are special, the following aspects of the International Year of Astronomy are relevant to setting up general global MSCPs and IYSs.

3.1. The need for a global relevant case

Astronomy as a science is especially suited to science communication. This is due to the fact that the sky is visible and accessible to everybody, whether they live in a developed or developing country. Astronomy touches on the largest philosophical questions facing humanity (Christensen & Russo, 2007), which brings astronomy closer to other cultural aspects of society. IYA2009 used these aspects to engage the public with the Universe. Although not all sciences appeal to the public to the degree of astronomy, in planning a MSCP, it is important to feature aspects of the project that are suited to engaging with and inspiring a large public. It is important to consider the activities that can best serve this purpose and showcase these in the project.

3.2. The need for advance planning

Planning MSCPs requires a considerable amount of time. Developing the case, framework and engaging the different stakeholders is a lengthy process and should start as early as possible. The planning for IYA2009 started in 2005, almost 5 years in advance (Table 3). This advance planning allowed the project to develop a solid framework (Table 2) and to engage diverse stakeholders (policymakers, research astronomers, amateur astronomers and science communicators). Evaluation usually does not start until the PE project is already underway. This might result in time, budget or data constraints for the evaluation process, which will affect the reliability and validity of the evaluation process. Project planning and evaluation planning should start at the same time.

3.3. The need for global coordination

MSCPs are mainly implemented by large numbers of unpaid volunteers. Hence, they often run into problems associated with low-performance of activity organisers. This problem is known as the reliability problem (Pearce, 1993) in volunteer organisations. The reliability problem is not easily solved, but a responsive coordination office supports the engagement of volunteers. Moreover, publishing regular reports and updates on the activities also induces a sense of ownership, pride, importance and respect from the global organisers. Avoiding the reliability problem is a crucial aspect in organising an MSCP (Boezeman & Ellemers, 2007). The establishment of the secretariat in mid-2007 as a small streamlined office to ensure global coordination played a vital role in addressing these issues during the implementation of IYA2009. Further, coordination was done via support and facilitation, not control. The secretariat acted as a catalyst and facilitator, providing a clear project framework (Table 2), standards, sets of procedures and information on the results. A global coordination office is an important component for the organisation

of science communication initiatives involving the participation of large numbers of geographically dispersed people, such as IYSs. We recommend that future MCSPs establish a coordination office in as early as the planning phase to ensure successful implementation.

3.4. The need for assessment and evaluation

Although conducting a professional evaluation of an MSCP is a difficult task, it is an important aspect of such a massive project and is needed to justify the expenditure to fund givers. Insufficient attention was paid to evaluation while planning and implementing IYA2009, and difficulties in evaluation were encountered. These difficulties were mainly due to late planning, budget limitations, lack of data, language differences and a lack of evaluation training provided to the individuals implementing the public engagement initiatives. These had negative implications for the validity, reliability and transferability of the IYA2009 evaluation. Below we discuss some recommendations for other MSCPs, such as the IYSs.

Insufficient budget. Allocating sufficient budget for evaluation was an issue with IYA2009 and is a general limitation. Frequently, public engagement projects face budget constraints, primarily because most projects do not include an evaluation budget. The budget limitations make it difficult to develop and apply the most appropriate evaluation instruments effectively. Project organisers may address budget constraints by simplifying the evaluation design; revising the sample size; exploring other data collection methods (such as using volunteers to collect data, shortening surveys, or using focus groups) or looking for reliable secondary data (Bamberger, 2004).

Other limitations. If evaluation is initiated too late into the program, insufficient baseline data poses a problem. Another possible problem that may compromise evaluation data, and must be tackled, is systematic reporting biases or poor record-keeping standards. This is a major issue for MSCPs. Data constraints may also result from difficulty in reaching and collecting data from a specific target group; for example, it is difficult to record the number of 'walk-ins' in an open-air exhibit. Evaluators can address data constraints by, for example, reconstructing baseline data from secondary data (Bamberger, 2004).

Language and culture. Cultural aspects, such as language, influence many facets of the evaluation process, including data collection, implementation of the evaluation program and the analysis and interpretation of the evaluation results. Language can be a major barrier to communicating concepts that the evaluator is trying to access, and translation is often required (Ebbutt, 1998). Thus, evaluators need to take this into account when planning the evaluation process (Bulmer & Warwick, 1993).

Need for training. It is important to provide basic training in the basic principles of impact evaluation design for national organising committees. The training materials and resources should include information about the follow-

ing evaluation principles: comparable pre-test/post-test design; focus groups; instrument development and testing; random sample selection, etc.

Several authors (e.g., Bamberger, 2004) have offered new suggestions for addressing these impediments to MSCPs: plan the evaluation strategy from the design phase; explore options for dealing with constraints related to costs, time and data; identify the strengths and weaknesses (threats to validity and adequacy) of the evaluation design; and take measures to address the threats and strengthen the evaluation design and conclusions from the design phase of the project. A central coordination office can act as the lead for the development of an evaluation strategy from the design phase.

4. IYA2009 Legacy

From its inception, IYA2009 was envisaged as more than just a series of activities occurring over twelve months; it was seen as a springboard for the popularisation of astronomy with a much longer timeframe in mind. While planning a global MSCP, the long-term sustainability and effect of the project and its legacy should be considered and taken into account from the beginning.

Several global astronomy projects have continued beyond 2009. For example, the designation of astronomical sites by the UNESCO World Heritage program has made significant progress since 2009 (Ruggles & Cotte, 2011). More work remains to be done in the coming years, but protecting and preserving our astronomical cultural heritage for future generations to appreciate must remain a priority.

IYA2009 also provided a less-stereotyped image of scientists and astronomers, through both the Cosmic Diary blog, in which working astronomers posted entries about their work, and the 'She is an Astronomer' project, which promoted gender equality. The stereotype of astronomers as oddball figures with long beards in towering observatories is not only inaccurate, but also damaging to the field (Buldu, 2006). Helping to reshape preconceptions and expectations is notoriously difficult, and the extent to which IYA2009 has had a positive impact in this area will be monitored over time (Frade et al., 2011). Discussions must continue to address the gender-balance issue in astronomy, as highlighted in the 'She is an Astronomer' project. The project has revived the debate on gender issues in astronomy, and several projects have started at institutional level.

Several filmmakers have produced movies that serve as excellent examples of the tangible, lasting legacy of IYA2009. The film 400 Years of the Telescope (Oman & Koenig, 2008) gave rise to a widely distributed planetarium show that will continue to fascinate and educate the public for many years to come. Robert Pansard-Besson produced the film Tours du monde, tours du ciel for IYA2009, and it was aired on the French-German channel Arte in November 2009, and continues to appear regularly on this and other TV channels around the world. Additionally, Eyes on the Skies, an IAU-produced educational movie that celebrates the 400th anniversary of the telescope, is expected to be frequently screened in classrooms, astronomy clubs and

homes around the world, as it has been subtitled in many languages (Schilling & Christensen, 2011).

Combining increased opportunities for developing nations with improved education, the Universe Awareness project (UNAWE) openly tackled some challenging issues during IYA2009. Its aim of creating an international awareness of our place in the Universe and on Earth, targeted at children in underprivileged environments, has inspired many. The program has received considerable support beyond IYA2009 (Ödman-Govender & Kelleghan, 2011; Schrier, Nijman, & Russo, 2013).

Over 2009, and ever since, developing nations have enjoyed increased access to astronomy groups and organisations at home and abroad. New openings and opportunities at both the professional and amateur levels initiated during IYA2009 are set to increase, making the best use of the expertise within these countries and helping global astronomical research and science communication. The IAU remains at the forefront of these efforts, and the IAU Strategic Plan for Astronomy Development identifies the consolidation of links between the IAU and developing nations as a priority. From the IYA2009 networks, we know that efficient global coordination is the foundation of success. The IAU Offices of Astronomy for Development and for Astronomy Outreach (based in Tokyo, Japan) will continue the work started during IYA2009.

5. Conclusions

IYA2009 has received considerable positive feedback. While the impact of IYA2009 on the scientific literacy of the general public will take time assess, there is little doubt that the communication of astronomical research throughout 2009 has contributed to an increase in the public understanding and appreciation of science. IYA2009 facilitated an increased awareness that we are living in an extraordinary era of discoveries about the Universe; introduced a less stereotypical image of astronomers to the public; demonstrated that a career in astronomy is also for women and minorities; created international networks of scientists, communicators, teachers and amateurs that remain in existence far beyond 2009; produced a wealth of educational material on astronomy in the form of books, films, movies, planetarium shows, and astronomy-related theatre and music productions; and inspired a new generation of amateur and professional astronomers.

On the basis of our experience with implementing and evaluating IYA2009, we here present several recommendations that should be taken into account while designing future MSCPs: MSCPs should be based on strong and relevant science cases. They should engage with a large number of stakeholders not only in science, academia and governance but also in less traditional communities, like artistic communities. The organisers implementing the projects at local level should feel a sense ownership, pride and importance towards the implementation of MSCPs. The global coordination body should ensure that this is the case. Planning (including evaluation) should start as soon as the concept is developed. Experts in the evaluation of science communication

programmes should be included in the global coordination team from the start and provide input to the MSCPs.

IYA2009 was the first event that brought a large network – consisting of 148 nations – together on a single science communication venture. This brief account should provide a head start and support to other organisers of MSCPs. It is also expected that the new International Years or other MSCPs will use some of the approaches, strategies and recommendations devised by the International Year of Astronomy 2009.

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